

ABSTRACT

The research project was carried out centred on developing Abnormal Load Advisory System to increase its efficiency in service delivery by automating all the expertise involved into a computerised system. With this understanding the researcher developed the Abnormal Load Advisory dissertation was crafted. The system brings about the history of Ministry of transport and Infrastructural Development as well as its current state. The dissertation emphasises on safety on both the road infrastructure and the road users as it advises the abnormal load vehicle operators on the maximum loads that their vehicles can move on the roads without damaging the roads as well as the other road users. To have a more detailed understanding of the system; interviews were conducted; questionnaires were distributed; observations were made and record inspections were done. Through the research, the organisation's value and ability to undertake the project was exposed considering the availability of most of the necessary resources which included time, hardware, software and the human resource. After a close scrutiny of the findings, it was discovered that software development tools to be used included PHP, MySQL database, Java Script and Mozilla Firefox browser. Basic system functionalities of the current system described using data and process modelling techniques were employed which included data flow diagrams, use case diagrams, entity relationship diagrams, package diagrams and sequence diagrams. Furthermore, design of the new system was described through highlighting menu, interface and output models to be designed. All the logical structures were turned into specific tested instructions executed by computer system. Different change over methods were explored from which one method was selected after considering influencing factors such as risk control, pace of change and need for facilitation of change. A comprehensive user manual was created so that any challenges faced pertaining to how to use the system the users would refer to the manual. The manual compliments the user training that was conducted during the implementation of the system. To take care of user requirements system maintenance will be provided when need arises.

DECLARATION

I George Itai Magombeyi, hereby declare that I am the sole author of this dissertation. I authorize the Midlands State University to lend this thesis to other institutions or individuals for the purposes of scholarly research.

Signature_____

Date_____

APPROVAL

This dissertation title “Abnormal Load Advisory System” by George Itai Magombeyi meets the regulations governing the award of the degree of BSc Honours in Information Systems of the Midlands State University and is approved for its contribution to knowledge and literal presentation.

Supervisor _____

Date _____

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Lastly to my beloved wife Netsai Kanyemba Magombeyi, family and friends for their continued support and encouragement during the time of my academic carrier. God bless you.

DEDICATION

“I dedicate this dissertation to my wife, Netsai R. Kanyemba Magombeyi, son Tapiwanashe and daughter Rudo as they were my source of inspiration. This work should inspire them in their future academic endeavours. Furthermore this work is dedicated to all those who believe that education is empowerment”.

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LIST OF ACRONYMS

AALAC	Application for Abnormal Load Advice Certification
ACAV	Advice for Certification of Abnormal Vehicle
ACAVC	Application for Certification of abnormal vehicle combination
ALAP	Application for Abnormal Load Permit
ALAS	Abnormal Load Advisory System
CVR	Central Vehicle Registry
DoR	Department of Roads
ESWM	Equivalent Single Wheel Mass
GCM	Gross Combination Mass
GVM	Gross Vehicle Mass
MICT	Ministry of Information Communication Technology
MOTID	Ministry of Transport and Infrastructural Development
NPV	Net Present Value
NRZ	National Railways of Zimbabwe
NVM	Net Vehicle Mass
PFMS	Public Finance Management System
PPA	Payback Period Analysis
ROI	Return on Investment
SADC	Southern African Development Community
TREDCO	Tyre and Rim Engineering Data Committee
VID	Vehicle Inspection Department
WBS	Work Break Down Structure
ZINARA	Zimbabwe National Roads Administration
ZIMASSET	Zimbabwe Agenda for Sustainable Socio-Economic Transformation

ZRP

Zimbabwe Republic Police

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CHAPTER 1: INTRODUCTION

This chapter describes the background of Ministry of Transport and Infrastructure Development (MOTID) and its organisational structure, the vision and mission of the Ministry. Also, it is outlined when the MOTID was established through the ministry's history. Problem statement is described, outlining the need for carrying out the project. Being a government arm responsible for the safety of road infrastructure and road users, the project seeks to describe the design and implementation of abnormal load advisory system as outlined in the aim and objectives.

1.1 Background of study

MOTID is a Zimbabwean government arm responsible for construction and maintenance of roads as well as providing for traffic regulations on the roads for the safety of the road users and the roads and bridges safety as well. So MOTID through Department of Roads (DoR) and Vehicle Inspection Department have the responsibility of regulating the mass and size of load being transported using the roads. To protect the tremendous investment in roads as well as for the reasons of road safety, the permissible dimensions and masses of vehicle operating on public roads are limited by the Road Traffic Ordinance and Regulations. Under special circumstances a vehicle or load which does not comply with the provisions of Road Traffic Ordinance and Regulations, may be issued with special permit allowing it to operate for a limited period on public roads. Such a vehicle or load is termed an abnormal vehicle or load. So the system that does all the modalities of acquiring the abnormal load permit is called Abnormal Load Advisory System which thrives on preservation of road infrastructure and users safety. It is noteworthy that about 2% per annum of ZINARA revenue comes from Abnormal Load Permits (MOTID Statement of Financial Position, 2013).

The abnormal load advisory system is used to guide abnormal load permit processing officers in calculating loads using roads that exceed the permissible mass or size. The Road Traffic (Construction, Equipment and Use) Regulations, 2010 S.I. 154 of 2010 as amended lay down certain limits on Size, Mass and Loads for vehicles with the primary intention of protecting the roads from material damage and the public from hazard and unnecessary inconvenience. There is a provision in the Regulations for the Minister to exempt particular vehicles from certain requirements of the Regulations. The system involves registration of the vehicle, processing of

permit (calculation of Equivalent Single Wheel Mass which involves a lot of computations), determining the appropriate route to use basing on the load and the route capacity that is the amount of load and size that the road on particular route can accommodate without posing danger to other road users and damaging the road infrastructure. All these processes are done manually which is so cumbersome to the officers. The computations are done by expert engineers in the DoR because an ordinary clerk cannot do the computations and determination of route for a particular load. It is from this background that the researcher has found interest in researching on the system.

The research is in a bid to come up with an expert system that makes it possible for an ordinary clerk to just supply the system with simple input then the permit is produced and the route to be taken be determined by the system using a knowledge base.

1.2 Background of the MOTID

MOTID is one of Zimbabwe government arms as a ministry responsible for all the transport infrastructural and management services. MOTID was established in 1948 in the then Rhodesia, and was then named Ministry of Roads and Road Traffic. It was renamed Ministry of Transport and Energy in 1980 in the independent Zimbabwe as the Ministry acquired the portfolio of energy. In 2008, the ministry got an additional portfolio of communications and renamed once more to Ministry of Transport, Communications and Infrastructural Development and under the leadership of Minister Goche. Furthermore, in 2013 Ministry of Information and Communication Technology (MICT) was formed.

So the Communications portfolio was moved to MICT leaving the transport ministry as Ministry of Transport and Infrastructure Development under the leadership of Honourable Minister Dr.Obert Mpofu as the Minister of MOTID. It should be noteworthy that the Ministry then was guided by ZIMASSET, a national economic policy document that put the ministry under one of the four clusters of the economic blue print that of infrastructure. The Infrastructure cluster is focused on the habilitation of infrastructural assets and the recovery of utility services in Zimbabwe (ZIMASSET, 2013). Road safety management is one of the ministry's key result areas in the ZIMASSET document.

1.2.1 Functions of MOTID

The MOTID as a government ministry owes its character to the legislation from which the ministerial functions are crafted. MOTID Part A General Manual of 2000 states the laid down ministry activities as follows:

- a) Planning, construction, maintenance and abolition of roads and control of entry from outside Zimbabwe through roads.
- b) Controlling the use of public roads transport.
- c) Registration and licensing of road motor vehicles
- d) Driver license competence test.
- e) Control of roadside furniture and advertising.
- f) Drafting of transport bill and policies
- g) Inland water transport control including boating licensing and registration.

MOTID has an office in each and every province in Zimbabwe making it ten provincial offices so as to have its services cover the whole nation of Zimbabwe and VID depots in almost every town and border post. The Head office has the mandate to formulate and supervise all the ministry's policies, which is achieved through different departments of the ministry. Each department implements and execute its mandate within their jurisdiction as specified in the Public Service Statutory Instrument. The study mainly focuses on the Department of Roads (DoR) and Vehicle Inspection Department (VID) in especially on the abnormal load regulation exercises done by the two departments as they safeguard the road infrastructure and the road users.

1.2.2 Department of Roads

DoR as a department within the MOTID also is the department responsible for construction and maintenance of national roads thus fulfilling one of Zimbabwe Agenda for Sustainable Socio-Economic Transformation (ZIMASSET) clusters of infrastructure and utility. DoR has its own mission statement derived from the MOTID mission statement. This is so as to make the department be more specific as it aligns its mission to that of the mother ministry. The DoR mission statement is as follows:

To regulate and cost effectively supply and maintain the country's road transport infrastructure by mobilizing both public and private sector participation in issuing safe passage and promotion of sustainable growth.

Abnormal load is any load that exceed the legal load mass, size or both and that is indivisible or that it is more economical to move the load as a unit rather than disassembling it so that it meets the legal mass or size limits. So the DoR does the axle load computations and the loads cost then produce an exemption permit for the load. Payment of load is done at ZINARA and physical check of the load and vehicle is done at VID to check for compliance to the permit.

1.2.3 Vehicle Inspection Department (VID)

VID is yet another department of the MOTID. VID uses the permit acquired from DoR to physically check the load for compliance to the permit's specifications so as to maintain safe passage of the abnormal load through Zimbabwe's roads.

1.2.4 Organisational Structure

There are several types of organisational structure for instance divisional, line and staff, project, staff or functional authority and line organisational structures. MOTID has implemented the divisional organisational structure. Divisional organisation structure is whereby departments are formed based on the following criterion: function, product, geographic territory or project (Carrell, Elbert, Hatfield, Grobler, Marx, 2000). MOTID formed its departments based on the functions of the departments for instance, DoR has the function of construction and maintenance of roads. So it was made a department. The same applies to VID whose function is inspection and licensing of road motor vehicles. For MOTID organogram see **Appendix B: Organogram**.

1.2.5 Vision

To be a regional hub for world-class transport networks, logistics and services by the year 2020 (transcom.inc).

1.2.6 Mission

To facilitate, provide and manage transport infrastructure networks, logistics and services (transcom.inc).

1.2.7 Values

These are the values that guide our decision making and which we follow in implementing the Ministry of Transport and Infrastructural Development's vision, mission and goals:

- **Safety:** We protect the safety of the travelling public, our employees and the workers who build, operate and maintain our transportation and communications system.
- **Client Focus:** We learn from and respond to our clients to deliver quality, affordable services to Zimbabweans and visitors.
- **Efficiency:** We strive to gain maximum value from the resources entrusted to us for the benefit of our clients, stakeholders and shareholders.
- **Accountability:** We build the trust of customers, stakeholders and the public.
- **Diversity:** We honour and respect our individual differences to ensure equitable opportunities.
- **Sustainability:** We balance economic, environmental and community well-being in a manner that protects the needs of current and future generations” (transcom.inc).

1.3 Problem Definition

Failure of normal operations by National Railways of Zimbabwe (NRZ) has of late put more pressure on the roads as most goods are transported by road compared to rail like it used to be in the past. The DoR has only two personnel with knowledge on how to properly register and calculate abnormal load vehicles mass exemptions such that in the absence of these two experts; abnormal load vehicles permits cannot be produced. Furthermore, some roads and bridges are being damaged by abnormal load vehicles because the roads were not designed for heavy load. On the part of the operators it involves a lot of movements from one office to another for an operator to obtain an abnormal load certificate and permit as operator has to go to DoR offices where he/she makes applications and have the load per kilometre fees calculated then go to ZINARA offices for payment, he/she thereafter goes to police for clearance then back to DoR for permit collection as he/she presents proof of payment from ZINARA, lastly the vehicle is taken to VID on weigh bridge for physical checking before the load begins movement. It should also be noted that the damage done by the load on the road from point of loading to VID Weight Bridge goes unnoticed.

So it is the intervention of a computerised system that can alleviate these problems. Moreover, this day and age it is not acceptable to be using a manual system for such a business process that brings revenue to the nation.

1.4 Aim

Designing a computerised Abnormal Load Advisory Online System that can capture, calculate, monitor, analyse and determine suitable route for abnormal load vehicles on Zimbabwe's roads with the primary intention of continuity even in the absents of expert personnel. Ultimate aim of the system is to regulate size, mass and loads for vehicles with the intention of protecting the public from hazard and unnecessary inconvenience and the roads from material damage.

1.5 Objectives

- To make it possible to register units of a truck as independent units that is horse, trailer and dolly then maintain a repository of the registered units such that a combination of different registered units can be made without making new registration of the whole combination.
- To provide for one stop service in abnormal load regularisation modalities by making abnormal load permit application, registration, load payment be done in one office so as to save time and improve on efficiency of the system.
- To determine suitable route for particular abnormal load as some roads have different widths and designs including bridges on the route that have different load capacity they can accommodate in terms of size and weight.
- To issue abnormal load permits automatically generated by the system so as to reduce human errors in calculation of load per kilometre cost and axle loading of the vehicle.
- To provide for a safe movement of abnormal load vehicles in Zimbabwe through provision of abnormal load spot checks for compliance at any point. Operators sometimes load the vehicle beyond the permit limit especially when there is no VID weigh bridge from source to destination of operator. So they evade paying for the abnormal load.
- To avoid the use of fake permits as the system is an on-line, all the authentic documents can be checked from the database from anywhere there is internet at real time.

1.6 Methodology and methods

Methodology refers to the choice and use of particular strategies and tools for data gathering and analysis (Bryman, 2004). The methodology to be employed is waterfall design methodology. Waterfall design methodology is a model that provides for a stage by stage design methodology that has provides a thorough piece of work at every stage. It provides for smooth flow of activities during development as the outputs of one stage are the inputs of the next stage. This make the methodology attain high rate of probability of not failing.

1.6.1 Instruments

- Internet
- Books
- Journals and Articles
- Department of Roads manuals

1.6.2 Software Development tools

- MySQL database: MySQL has been chosen because of its popularity with most programmers, and also because of the following characteristics; affordability, relatively fast processing speed, reliability, advanced security features (Schwartz, Zaitsev and Tkachenko, 2012).
- PHP Hypertext Pre-processor : PHP is an acronym for Personal Home Page. PHP does not have costs attached to it such as update costs, licensing or royalty fees involved. It is every programmer and organisation to keep project costs as low as possible. It will be used to interface the system, data manipulation and report writing.
- PHP middleware: PHP middleware can be used on the major operating systems such as Windows, LINUX, many variants of UNIX and Mac OS, but in this research Windows 7 or 8 it is going to be used on.
- Wamp server: Wamp server is a windows based web environment which allows creation of application with apache, PHP and MySQL database.

- Apache is a web development tool that is used to facilitate for communication between application software and the database. Again Wamp is open source software.
- Mozilla Firefox is the browser to be employed because of its ability to tab browsing, blocking of pop-ups and provides for integrated search.
- Cascading Style Sheets Software (CSS) is the software used for styling of the web pages and user interfaces for them to be appealing to the users. This includes layout, colours and fonts.
- Hyper text markup language (HTML): A software used to build web pages which works hand in hand with CSS to produce a good web page. HTML forms the basis of a web page.
- Java Script: is a programming language used as part of the browser whose implementation allows client side script to interact with user, control the browser, communicate asynchronously, and alter the displayed document content

1.6.3 Data Collection Procedures

- Interviews
- Questionnaires
- Observation
- Record Inspection

1.7 Justification

The proposed automated electronic database system will minimise the enormous paperwork in the DoR and VID abnormal load business processes resulting in increase in physical storage space such as cabinet files. The system will minimise duplication of data among departments of the same ministry like DoR, VID and ZINARA. The system will make it possible for an ordinary clerk to issue out abnormal load permits which currently require a lot of mathematical computations to produce. The issuing officer will only capture the vehicle configuration variables then the system does the computations. It will also reduce time that is required to register an abnormal load vehicle

and issue out abnormal load permits. The proposed system will make it possible for operators to change some units of a vehicle without making a new registration, for example, any abnormal load registered horse can be used with any other registered trailers without making a new registration for the combination. Also, the proposed system brings about convenience to the operator in that registration, abnormal load permit application and payment can be done in at one stop without moving from one office site to another for the sole purpose of acquiring an abnormal load permit. The new system will enable the users to input data directly into the computer and the system will then determine the maximum load that the vehicle combination loading limits reducing human error in issuance of certificates. The system will automatically determine the route to be used by the abnormal load vehicle depending on the route's capacity (roads and bridge load designs along the route) to sustain the load

1.8 Conclusion

Abnormal load regulation is important for safety of both the road infrastructure and the road users. A lot of investment is made on road construction such that it is not fair to see the roads and bridge infrastructure be destroyed by load moving on it. To have the regulation be done efficiently and consistently, there is need to use a computerised system for Abnormal Load Advisory. This provides for safety to the public and the roads infrastructure thereby an improvement to the economy at large as the road plays a pivotal role in any economy in the world. It is from this background that a research study be carried out on the system. This will then lead into planning phase which constitutes Chapter 2 Planning Phase of this project. Planning phase looks at practicality of development of the system.

CHAPTER 2: PLANNING PHASE

2.1 Introduction

Planning in simple terms is defined as guide to action (Janet, 2012). This phase of the project looks at practicality of development of the system. Guiding the project to action involves the process of defining orderly arrangement of activities and resources in bid to deliver a required product thus communicating project activities. The activities are communicated through identifying the tasks to be performed, the persons to perform the tasks, times when the tasks are to be carried out and completed that is scheduling of tasks, sequence of execution of tasks and the resources required to accomplish the tasks (ITRM Guideline, 2006). Also, planning phase spells out the justification of developing the Abnormal Load Advisory System through examination of the business values realised from developing and implementing the system, as well as the feasibility of developing the system that is the practicality of the system.

2.2 Reasons for Building the System

What has prompted the building of the system are the drawbacks being experienced with the current system which are militating against MOTID's goals and values. The new system will bring about efficiency and effectiveness as far as abnormal load licensing is concerned as the system will be able to do the following;

- ✓ Perform the cumbersome calculations to determine the Equivalent Single Wheel Mass (ESWM) of abnormal load vehicles immediately after simply input of the vehicle configurations as supplied by VID automatically.
- ✓ Automatically determine the maximum load capacity of the vehicle after calculation of the ESWM.
- ✓ Determine the route that can accommodate the abnormal load from the source to destination without posing risk to the road and other road users.
- ✓ Determine the time of movement of the abnormal load so as to give room to other abnormal loads using the same route to avoid continuous strain on the road and inconveniences to other road users.
- ✓ Facilitation of spot checks thereby avoiding the use of fake permits as the system will make it possible to check the existence of an abnormal load permit in the database from anywhere via the internet as it will be an online system.

- ✓ Produce reports at any time thereby informing management on revenues collected from abnormal load movements, numbers of applications made per given time, routes that being frequently used by abnormal load and many other reports important for planning purposes.
- ✓ Integration MOTID departments; DoR and VID in carrying out their mandate of regulating abnormal load movement on the national roads for the safety of the road, road furniture and other road users.
- ✓ Standardise the whole process of abnormal load permit issuance.
- ✓ Advise the permit issuing officers on the status of registration of any particular abnormal load vehicle.

The system will also be able to guide abnormal load operators on how to load their vehicles without causing harm to their vehicles as the ESWM calculations will be made accessible to the public via the MOTID website.

2.3 Business Value

Strategic and tactical benefits derived from the introduction of the proposed system are referred to as business value (Spool and Hoekman, 2006). Business values are reviewed at the end of the project as they are spelt out in answering the questions that start with the phrase “Will it....:

- a.) increase revenue?
 - b.) decrease expenses?
 - c.) attract new customers or clients?
 - d.) make existing customers have confidence in the system?
 - e.) shareholders buy it in and participate?
- The system will result in increased revenue especially from foreign abnormal load vehicles in transit to Zambia, Malawi and Democratic Republic of Congo from South Africa. The system will be producing permits faster than current system resulting in reduction in waiting time at the border. So vehicles in transit to countries to the north of Zimbabwe will opt to transit via Zimbabwe than other alternative routes such as Botswana and Mozambique, bringing revenue in form of permit and tolling fees.

- Expenses are reduced in terms of stationary. The system will be storing information and data on electronic database using the existing computers in the Ministry rather than storing large volumes of paper using cabinet files. This shows means that there will not be any need to buy cabinet files to use as databases.
- The system will bring in new customers especially foreign abnormal load operators in transit to countries to the north of Zimbabwe. This will be so because of fast production of permits which results in no delays when crossing the borders into Zimbabwe as it will be just the physical verification of the load at the VID border weigh bridge. So new customers will obviously use Zimbabwe as transit corridor which is after provides the shortest routes to Zambia, Malawi and DRC from Durban Port in South Africa.
- The system will make existing customers have confidence with the system as the system can advise customers/operators on how to load vehicles of different configurations on the internet; meaning that operators are advised on how to load their vehicles in the comfort of their offices rather than having to visit DoR offices to acquire information on vehicle loading.
- Management as part of the stakeholders as well as financiers will buy in the idea of the new system as it is a move towards fulfilling one of ZIMASSET's key result area of E-Government under the infrastructure and utility cluster. Under the infrastructure and utility cluster there is Information Communications Technology (ICT) with one of its outputs as; "government systems automated" (ZIMASSET, 2013: 90). So the new system is rightfully supporting ZIMASSET hence the management will definitely buy the idea of the new system.
- The system will provides for data accuracy and consistency because of its use of SQL database system which upholds high levels of data accuracy and consistence, properties of good database system.
- The system will reduce waiting time for the production of a permit because of its use of computer processing power in searching and calculations involved in the production of a permit, unlike the current system which takes at least seven days to process a permit.

2.4 Feasibility Analysis

Feasibility analysis also referred to as feasibility study is the preliminary evaluation of the whole project through assessment of the worthiness of the project so as to see if the project can be

undertaken before committing resources to a project that will fail at the end. Feasibility study is a way to ascertain that benefits from the system outweigh the costs to be incurred in development and implementation of the system (Barringer and Ireland, 2006). This can be achieved by exploring the market potential of Abnormal Load Advisory System. If the benefits outweigh the costs then the project can go ahead otherwise stop before resources are wasted.

2.4.1 Technical Feasibility

Technical feasibility involves investigation of the human resources in terms of technical expertise and hardware gap (difference between available and that needed hardware) to see the project succeed. Of importance to be investigated on hardware are the hardware specifications on which the new system will run. There are essential technical aspects which that need to be established for every project to succeed. The essential aspects to be established are:

- a.) Of the available hardware how much is needed for the project?
- b.) Does the organisation have technical expertise to manage the project through to the end?
- c.) Terms and legal obligations surrounding procurement of new hardware and software.
- d.) Any licensing, trademarks or patents involved in the project.

2.4.1.1 Technical Expertise

- MOTID has a department of information technology which is composed of computer programmers, network technicians and systems analysts as is depicted by the organogram see **Appendix B: Organogram**.
- Availability of such staff compliment ensures smooth development flow of the system as these technical experts will be instrumental in the development and implementation of the system. The presents of network technicians enables the system to quickly go on line such that it is rolled out to all VID and DoR offices spatially located around Zimbabwe.
- Furthermore, training other staff members who are not computer literate will be done by the systems analysts of MOTID as it is part of their job description; to train other staff members on how to use the new system.

2.4.1.2 Hardware and Software Specifications

This specifies the availability of hardware and software needed by to see the project succeed. MOTID already has some of the hardware and software required by the new system. **Table 2.1**

that summarises the available hardware and software, the recommended hardware/software specifications for the new system which are the minimum specifications requirements.

Item (Hardware/Software)	Recommended	Available
Server	4 GHz 64-bit processor, 1 TB HDD, 8GB memory,	4GHz dual core 64-bit four core processor, 2 TB HDD, 8GB memory
DoR and VID provincial offices workstation	1.6 GHz processor, 300GB HDD, 2GB memory	2.4 GHz processor, 300GB HDD,
Backup media	Google Drive and DVD/CD writer.	DVD/CD drive and flash disk
Wamp server	Wamp server2.1	Wamp server2.1
Apache2	Apache2	Apache2
PHP	PHP	PHP
MySQL	MySQL	MySQL
PhpMyAdmin	PhpMyAdmin	PhpMyAdmin

Table 2.1: Hardware and Software Specifications

2.4.2 Economic Feasibility

Economic feasibility is an accurate budget compilation showing the costs to be incurred during system development. This is the budget used by the project financiers to make a decision on whether to carry out the project or not (Horngren, Bhimani, Foster and Datar, 1999). In the case of MOTID, it is the Finance Department, the Secretary for Ministry and sometimes the Minister who can make the decision. A report called Cost Benefit Analysis (CBA) will accompany the project budget. The CBA depicts an assessment of the cost to be incurred against the benefits to be realised. Comparison of costs against benefits is considered when making a decision on whether to go on with the project or not. There are also other tools used to make a comparison of cost and benefits as one tool alone cannot suffice. So some of the tools used are Payback Period, Cost-Benefit Analysis, Return on Investment (ROI) and Net Present Value (NPV) (Hughes and Cotterell, 2009).

2.4.2.1 Cost-Benefit Analysis (CBA)

CBA estimates and sum up the equivalent monetary value of benefits and costs to community of project to evaluate their worthiness (sjsu.inc). All the costs and benefits are converted to their monetary equivalents so as to have a common unit of measurement. There are however, two major categories of benefits and two major categories of costs which are tangible and intangible benefits and, development and operational costs (Hughes and Cotterrell, 2009). These categories of benefits and costs are summarised **Table 2.2**.

2.4.2.1.1 Tangible Benefits

Tangible are quantifiable gains realized from an activity. Tangible benefits are those gains that are easily converted into monetary value using a unit of measurement without using estimation techniques (Dryry, 2000). In the ALAS, tangible benefits include reduction in stationary costs, increased office space and reduced overtime allowances. Office space will be increased as the system will make use of electronic database to store records rather than the cabinet files which consume relatively more space than the computers which house the databases. Space is charged per square meter so the reduction in space occupied by cabinet files can be easily worked out to its monetary value.

Tangible benefits

Benefits	USD \$
Increased office space	1,000.00
Reduced stationary costs	2,000.00
Reduced overtime allowances	2,000.00
Total	5,000.00

Table 2.2: Tangible Benefits

2.4.2.1.2 Intangible Benefits

These are gains realized from an activity but are not easily converted into their monetary value, they are usually associated with employee attitude and public perceptions (Jefkins and Yardin, 1998). Jobler and Lancaster (1997) argues that employee happiness is an example of intangible benefit and a happy employee is a productive employee. However, employee happiness is a

benefit that cannot be easily converted into its monetary value without using estimates. Other intangible benefits include:

- **Improved system efficiency**

System efficiency is measured by calculating the time it takes the whole process of an operator to acquire an abnormal load permit from the time of application. This time measurement cannot be easily converted into monetary value without estimation of some measurements.

- **Improved security**

Using a computerized system will improve the system as access to the system information is restricted by the use of passwords and access levels. This is a benefit that is intangible and cannot be easily converted to its monetary value as there is no unit of measurement for security.

- **Improved system credibility**

Using a computerized system brings about standardization of the system which makes the system credible to the users as it will be standard wherever it is being used.

Credibility has no unit of measurement to calculate its monetary value hence qualifying it to be an intangible benefit. A credible system makes the users have confidence in the system which is a benefit to the organization.

2.4.2.1.3 Cost

Costs are expenses associated with acquisition of something (Dryry, 2000). The costs are divided into two categories which are operational costs and development costs. Development costs are total expenses incurred from project initiation up to implementation phase and the subsequent expenses are operational cost (Owler and Brown, 1990). Development costs include expenses associated with the following facets:

- Creative design and implementation
- Training and conversion
- Printing, stationary and electricity

The subsequent costs are referred to as operational costs which include:

- Travel and subsistence allowance costs
- System maintenance costs

- Electricity, printing and stationary expenses.

Converting the benefits and costs in **Table 2.2: Tangible Benefits** into their money value using estimation can provide for a more detailed CBA as presented in **Table 2.3**.

Year :	1	2	3	4	5
	USD	USD	USD	USD	USD
TANGIBLE BENEFITS	\$	\$	\$	\$	\$
TOTAL BENEFITS	19,500.00	18,000.00	21,300.00	21,400.00	21,500.00
TOTAL DEVELOPMENT COST	10,200.00	1,800.00	1,000.00	5,000.00	5,000.00
Creative design and development	3,000.00	1,000.00	500.00	-	-
Printing, stationary and electricity	1,000.00	800.00	500.00	500.00	500.00
Training and conversion	3,000.00	-	-	-	-
TOTAL DEVELOPMENT COST	7,000.00	1,800.00	1,000.00	500.00	500.00
OPERATIONAL COST					
Travel and subsistence allowances	2,000.00	1,500.00	300.00	200.00	100.00
Hardware maintenance	200.00	800.00	1,000.00	1,200.00	1,300.00
Software maintenance	200.00	600.00	600.00	400.00	200.00
Electricity, printing and stationary	800.00	1,000.00	400.00	400.00	400.00
TOTAL COST	10,200.00	5,700.00	3,300.00	2,700.00	2,500.00
NET BENEFIT/(LOSS)	9,300.00	12,300.00	18,000.00	18,700.00	19,000.00

Table 2.3: Detailed Cost Benefit Analysis

The detailed CBA explicitly shows that the benefits outweigh the costs involved. This is shown by having positive net benefits hence the project is economically feasible. However, more detail is required to explicitly evaluate the project worthiness. So other tools are employed to further evaluate the project.

2.4.2.2 Payback Period Analysis (PPA)

Payback period analysis is the time it takes for a project to get to a point of breaking even, that is how much time it takes for the project to recover the initial investment expenses (Horngren et al, 1999). Initial investment costs is derived from sum of development costs in the first year which is

\$7,000.00. PPA is simple to calculate and is not particularly sensitive to small forecasting errors. PPA is arrived at after dividing net initial investment by uniform increase in annual cash flows the multiply by 1/12 months in a year for the first year of investment and period is in months as illustrated in **equation 2.1**.

$$\text{Payback} = \frac{\text{Net initial investment}}{\text{Uniform increase in annual cash flows}} \quad \dots \text{Equation 2.1}$$

Source: Horngren et al (1999)

Initial investment = \$7,000.00, Net profit = \$9,300.00

$$\begin{aligned} \text{PPA} &= (7000/9300) \text{ multiply by } 12\text{Months} = 9.032 \\ &= \text{about } 9 \text{ Months} \end{aligned}$$

So it takes about 9 months for the project's initial investment to be recovered which is not a very long time when considering the size of the project. So the project is feasible. PBA's drawback is that it ignores the overall profitability of the project. It totally ignores any income or expenses that come after the project gets to break-even point. For this reason there is yet another tool to be employed so as to evaluate the economic feasibility of the project that may take into consideration the income and expenditure after payback period. The tool to be used is Return On Investment (ROI) (Horngren et al, 1999).

2.4.2.3 Return On Investment (ROI)

ROI also known as Accounting Rate of Return (ARR). ROI provides a way of comparing the net profitability to the investment capital (Randall, 1996). ROI provides a simple easy to calculate measure of return on capital invested. ROI is calculated as follows:

$$\text{ROI} = \frac{\text{Increase in expected average annual profit}}{\text{Net initial investment}} * 100\% \quad \dots \text{Equation 2.2}$$

Source : Randall (1996)

The following table shows the calculated ROI. The calculations have been done using MS Excel where the formulae was employed.

Year	Net Annual Profit (\$)
1	9,300.00
2	12,300.00
3	18,000.00
4	18,700.00
5	19,000.00
Total Profit in 5 years	77,300.00
Average profit	15,460.00
ROI/ARR	22.10%

Table 2.4: Return On Investment ROI

The ROI is 22.1%, a positive rate which indicates that the project is favourable. However, ROI suffers from two severe drawbacks which are:

- The tool takes no account of the timing of cash flows. All it provides is a rate at which the initial investment is returned without giving any detail on the cash flows.
- This rate of return bears no relationship on interest offered by banks or any other interest rate since it takes no account of the timing of the cash flows or of compounding interest. It is therefore misleading

These drawbacks makes it worthwhile employing yet another project evaluation technique which takes into consideration the timing of cash flows and interest rates. The technique that can do this is Net Present Value (NPV).

2.4.2.4 Net Present Value (NPV)

NPV is yet another project evaluating technique that takes into consideration the profitability of the project and timing of cash flows produced. It is based on the premise that a dollar received today is better than a dollar received tomorrow. The dollar could for example be invested in a bank today and have dollar plus interest earned tomorrow (Owler and Brown, 1990). If for example, the present value of \$100 received in a year's time is \$90, it means that \$100 in a year's time is equivalent to \$90 now. This is caused by inflation and discount factors; economic factors not considered by other project evaluation techniques. The example given shows that future income is discounted by 10%. Vice versa, if \$90 is invested in a bank and translate to \$100 in a year's time

then there is an interest rate of 10% (Hughes and Cotterell, 2009). So this shows that the value of money dynamic depending on the economic factors such as interest and discount rates.

Net present value is the sum total of all the present values throughout the project life (Randall, 1996). Discount factor is calculated as illustrated by **Equation 2.3**

$$\text{Discount factor} = 1/(1+r)^t \quad \dots \text{Equation 2.3}$$

Source: Horngren et al (1999)

Where: **r** is Discount rate usually expressed as decimal

t is time (number of years into future in which cash flow occurs)

Cash flow figures come from the annual net profit from CBA table. The discount rate to be used is the Reserve Bank of Zimbabwe (RBZ) discount rate which is 7.17% established in 2010 (Theodora.inc).

Year	Cash flow	Discount factor (7.17%)	Present Value
0	9,300.00	1	-9,300.00
1	12,300.00	0.9331	11,477.13
2	18,000.00	0.8706	15670.80
3	18,700.00	0.8124	15191.88
4	19,000.00	0.7580	14,402.00
NPV			47,441.84

Table 2.5: Net Present Value Calculations

It is noteworthy that when using the NPV technique, a positive NPV is an indication that the project is feasible (Hughes and Cotterell, 2009). So it is safe to conclude that the project is feasible as it is giving a positive NPV of \$47, 441.84 at 7.17% discount rate.

All the project evaluation techniques have shown that the project is feasible. So the project can be said to be economically feasible.

2.4.3 Social Feasibility

Social feasibility focuses on the system's impact to the society both negatively and positively. The pivotal role for the development of the system is to improve service delivery and safety to the road users who make up the society (Lafferty, 1982). Putting the system in place ensures safe loading and travelling dates for abnormal load thereby upholding safety to both the road and the users.

Furthermore, the internal system users that is the DoR and VID staff will no longer have to work over time to clear backlog, giving the members of staff more time to do other social activities after normal working time. There are not any negative social implications identified with the system.

2.4.4 Operational Feasibility

Operational feasibility is all about how the system is being accepted by the stakeholders (Neeman and Sarlin, 2007). This shows how the stakeholders are taking the system on board. The new system ties well with the MOTID goals of providing safety to the road users and the road infrastructure. So the new system will operate smoothly. Most of DoR and VID staff are computer literate because of their use of computers and other information systems such as the Public Funds Management System PFMS used by all government ministries and departments in some of the daily operations. The following are characteristics of the new system that facilitates it being operationally feasible:

- Well documented manuals to help users navigate through the system.
- Training is going to be offered to all the users of the system before and during implementation.
- Simple user interface making use of pictures which are easy and quick to interpret (Neeman and Sarlin, 2007).

2.5 Risk Analysis

Risk analysis involves identifying undesirable event occurring in the project that may result in the failure of the project (Sommerville, 2001). Also involved is the impact of the identified risk if it occurs. It is impossible to completely eradicate risk but performing risk management ensures that are taken at the right time whilst minimising the impact. Risks involved are identified, analysed, risk impact assessed then find measures to combat the risk. Risks are categorised into technical, economic and operational risks. These are the major categories of risks (Hughes and Cotterell, 2009). Risks call for a proactive approach to be mitigated. To achieve risk mitigation there must be a risk plan in place that include immediate response or dealing with a problem as soon as some signs of risk begin to show or when anticipating for an unforeseen adverse event occurring. Sometimes, risk is transferred by having an insurance for the system such that if the system fails

then damages are recovered from insurance (Yeates and Cadle, 1996). However, insuring a system is very expensive. So the best way is to have a risk plan management plan. **Table2.6**

Risk Category	Probability of risk occurrence	Impact	Preventative measure
Economic Risk Zimbabwe is not using local currency and as such there is no control on the availability of cash.	Less likely to affect the project as the use of other currencies is possible such as Rand, Pula, British Pound and Euro.	High	Pay for the all the necessary resources well ahead in time and stock the resources.
Technical Risk <ul style="list-style-type: none"> - Virus - Network failure - PC failure 	Because of the use of internet there is high probability of virus attack from the internet	MEDIUM	Have an up-to-date anti-virus software in place. -frequent check of availability of network.
Operational Users resistance	This is less likely to occur because automation of all government systems is a move that is clearly spelt out as one of the key result areas of infrastructure and utility cluster in the ZIMASSET document	HIGH	Involve the users during development and train every user to understand the system and its significance to their daily work.

Table 2.6: Risk Analysis

2.5 Work Plan

Having the project being feasible, it is befitting to come up with work plan. Work plan involves identification of milestone activities of the project and sequencing them in order of execution showing when each activity start and end (Jain, 2002). This shows the whole project's schedule of activities in chronological order so as to guide the project team on getting the project up and running in time. So scheduling of the project's milestones gives guide to the development as well as a reporting tool to management on project progress (Jain, 2002). To illustrate the work plan a Gantt chart is used. Time planning is shown in **Table 2.7**

Phase	Commencement date	Completion date
1. Proposal	15/12/14	10/01/15
2. Planning	26/01/15	09/02/15
3. Analysis	10/02/15	24/02/15
4. Design	25/02/15	11/03/15
5. Implementation and Testing	12/03/15	23/04/15
6. Documentation	10/12/14	20/05/15

Table 2.7: Work Plan

2.5.1 Gantt Chart

Gantt Chart is a project management tool used to depict the start and end times for project tasks and sub-tasks (Techmedia, 2012:1007). Gantt charts is derived from work break down structure (WBS). **Fig 2.1: Gantt Chart** is a Gantt chart using bars extending from left to right along horizontal axis to denote starting and ending times for activities or phases of the project.

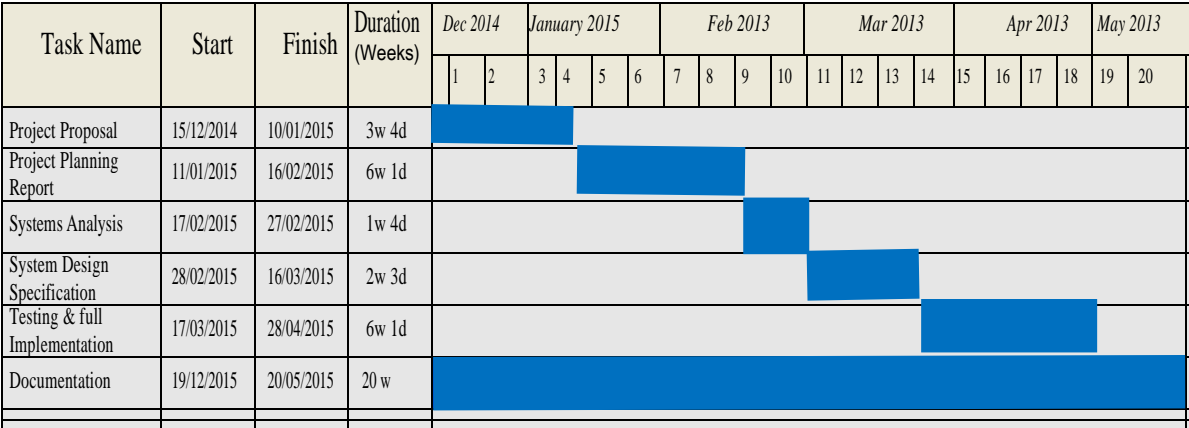


Figure 2.1: Gantt Chart

2.6 Conclusion

Planning phase is the stage where the project is evaluated for its worthiness through feasibility analysis. This is the stage where bold decision is taken on whether to go ahead with the project or not depending on the viability of the project. Also this is where all the planning of the project is

defined such that all the phases that follow will have their bearing from planning phase. Identification and scheduling of activities is done at this planning phase. Having all this in place, the next phase is the analysis phase which makes chapter 3 of the project. Analysis phase focuses on what the current system do and how it operates. In short, analysis explores the input, processes and outputs of the current system. This is done using information gathering techniques.

CHAPTER 3: ANALYSIS PHASE

3.1 Introduction

Analysis phase is the third phase of the project that involves an in-depth study of the current system. It is based on the inputs, processes and outputs involved in the current system. The current system processes are explored to see how they interact to form a system. By so doing, an important question of the project is addressed. The important question is; “What does the system do?” In order to gain insight into the current system, fact gathering techniques are employed such as interviews, observations and questionnaires. It is from these fact gathering tools that the strengths and weaknesses of the system are identified, leading into identification of alternative solutions. The strengths and weaknesses of the alternatives are evaluated resulting in coming up with the best solution among alternative solutions thus the proposed system. Analysis phase deliverables also include functional and non-functional requirements of the proposed system. Aim of analysis is to produce a requirements specifications (French, 1998)

3.2 Information Gathering Methodologies

Methodology is both detailed research methods through which data are collected, and more general philosophies upon which the collection and analysis of data are based on (Haralambos and Holborn, 1995). Information gathering methodologies were employed in order to gain an informed research about the current abnormal load advisory manual system. The methodologies employed were interviews, questionnaires and observations. Data collected were from both internal and external stakeholders. Stakeholders are entities who have an interest on the system which includes the internal and external users of the system (Yeates and Cadle, 1996). The reasons for employing the information gathering methodologies were to:

- have an understanding on what it takes for a load to qualify to be an abnormal load
- have an explicit analysis of the current system that is the basic inputs of the system
- identify all the stakeholders of the system
- have an insight into different users’ needs on the system to be developed.
- identify the problems with the current manual system.
- Identify and evaluate the best way to implement the proposed system

It is important to gather all the facts about the current abnormal load advisory manual system to ensure that all the strengths and weaknesses are discovered. “Thus when a new system is designed as many as the weaknesses as possible are eliminated, whilst retaining the strengths” (French, 1998:227)

3.2.1 Interviews

Interview is a fact gathering technic that involves face to face or long distance discussion between the interviewer and interviewee in which the interviewer collects information and opinions of the interviewee (French, 1998). Interviews take a number of forms depending on how structured they are. A completely structured interview is simply a questionnaire administered by an interviewer who is not allowed to deviate in any way from the questions provided. “Interviewer simply reads out the questions to the respondent” (Haralambos and Holborn, 1995:839). The other form at the extreme is unstructured interview which takes the form of conversation where the interviewer does not have predetermined questions. The form of interview employed was between the two extreme forms of interviews that is between structured and unstructured interview (**see Appendix D**). Most interviews fall between structured and unstructured form (Haralambos and Holborn, 1995).

Interview process involved identification of the interviewees from the system’s stakeholders which includes both internal and external stakeholders, the areas to be covered by the interviews, timing and scheduling for the interview. Main focus of the interviews was seeking clarification on unclear areas and acquire the stakeholder’s opinions on the strengths and weaknesses of the current abnormal load advisory manual system. In order to avoid bias and prejudice to the response, context free questions were employed. Context free question refers to non-directive questions which according to Tricker and Boland (1990) is refrain from offering opinions and avoiding expression of approval or disapproval. This was achieved through creating rapport with the interviewee prior to the actual interview. French (1998) argues that interviews are the most widely used technique and very productive.

3.2.1.1 Advantages

- First-hand information was obtained from the actual users of the system.
- Relatively faster in obtaining feedback as it was instantly obtained from the interviewees.

- More comprehensive information was obtained as non-verbal expressions were also employed to augment verbal expressions in expressing opinions by the interviewees.
- Interviews make it possible for issues to be explored to greater depths as the interviewee is not limited to choices in their response.
- The questions structure could be changed depending on the prevailing mood and character of the interviewee without of course changing the aims of the question.
- Interviews were useful in generating new hypotheses and theories which were not initially thought of. It was during interviews when it was discovered that the abnormal load transport operators as customers of the system need to use the system from their work places so that it advises them on how to load their vehicles.

3.2.1.2 Disadvantages

- Outcome of responses strongly depend on the communication skills of the interviewer.
- It is difficult to organise interviews as they interfere with the daily operations time of work. So a convenient time for both the interviewee and the interviewer needs to be set carefully.
- Not all the information can be disclosed for security reasons or fear of victimization.
- The use of non-verbal expressions can be misleading as there is no standard in the use of non-verbal communication.

3.2.2 Questionnaires

A questionnaire is also another fact gathering technique that was employed to gather information about Abnormal Load Advisory System. Questionnaire is a special-purpose document that allows collection of information and opinion from respondents (Whitten, Bentley and Barlow, 1996). The document can be mass produced and sent to respondents so that they can complete the questionnaire at their own time. Questionnaire was employed because some of the respondents were too many and they were geographically spaced, especially the abnormal load operators. According to Whitten *et al.* (1996), using questionnaires allows gives room for facts to be collected from a large number of people while maintaining uniform responses. It is regarded as the best fact finding technique when using large audience to tabulate the same facts. Questionnaires were prepared and distributed to several abnormal load operators across the nation and some from within the region. Some of the abnormal load operators are based in other countries especially South Africa, Zambia and Malawi.

3.2.2.1 Advantages

- Respondents had the room to answer the questionnaire at their convenience thereby reducing disturbances.
- A relatively inexpensive way of gathering data from a large number of individuals that are geographically spaced.
- Questionnaires maintains anonymity which makes the respondents more likely provide real facts without fear of victimization.
- Analyzing and tabulating the responses is relatively quick.

3.2.2.2 Disadvantages

- Number of respondents was lower than expected.
- Some of the respondents did not answer or expand on all of the questions.
- Questionnaires were inflexible, that is to say that there was no room for voluntary information obtained from respondents.
- There was no complementary communication to aid in explanation such as non-verbal communication hence it was difficult to get to the exact meaning of the responses.
- It was difficult to prepare a good questionnaire as it involved assuming several different personalities so that the questionnaire could not offend anyone.
- There was no immediate opportunity to clarify vague answer.

3.2.3 Record Inspection

Record inspection is the study of organisational charts, procedures and statistics which reveal useful information about a procedure (French, 1998). The forms being used in the current Abnormal Load Advisory System were studied to gain an insight on the flow of data in the system. Furthermore, there is also a manual; Part K Manual that explain the procedures involved in the system, explaining each and every procedure. The manual is the guide to all the procedures involved. French (1998) argues that a close study of the current forms being used should give the best guide to current practice which may, or may not accord with the original requirements.

3.2.3.1 Advantages

- Records provided for a consistency in the procedures involved as it is the manual of the system for example in the case of the Part K, a manual for DoR on procedures involved in Abnormal Load Advisory System.

- Knowledge about the current system was acquired through the actual data that was used in the system's application forms for example.
- There was no interference from users as the system study could be carried out from reading the system records without any user explaining the processes.
- Manuals reveal a standard for the system. Manuals are laid down procedures of a procedure that shows the sequence in which events follow and how the events are undertaken. Compared to interviews and questionnaires, manuals quickly show the system standards.

3.2.3.2 Disadvantages of Record Inspection

- Assumptions were made in areas where the records were not clear hence giving misleading information at times.
- Some of the records especially filled in forms have some omission errors such that they were misleading.
- The ink used to fill in the form is fading away making it difficult to read and understand the data.

3.2.4 Observation

An observation is a fact finding technique that involves watching. According to Dooley (1998), observation is best employed in conjunction with other techniques and is done only after the procedures involved are understood how they work. Only then can irregularities be observed thus observing strengths and weaknesses of the current abnormal load advisory manual system. Observation technique takes two different forms and that is participant and non-participant observation (Jain, 2002). Participate observation is whereby the researcher observes the procedures as he or she carryout the procedures whilst non-participant observation is gathering facts by watching (Briony and Oates, 2006). So non-participating observation was used to gather facts on the Abnormal Load Advisory System. Procedures from application of the abnormal load permit to up until issuance of the permit were observed.

3.2.4.1 Advantages

- First-hand information was obtained as observation involves gathering information from procedures during normal daily operations.

- It was relatively simple to administer as there was no involvement of setting up appointments was the case with interviews where some appointments were never honoured.
- Users daily operations were never disturbed as the technique involved observing without talking to the users which could have otherwise made the users stop their operations and try to explain procedures to the data collector as was the case with interviews.
- Information about the operations of the business procedure is obtained excluding the system users' opinions and comments that may be biased such that the information gathered is misleading.

3.2.4.2 Disadvantages

- Acting up of members of staff when they are aware that they are being observed. Normally, people tend to stage up how they normally work if they know that they are being observed. So some operations were to some extent exaggerated.
- It calls for a lot of experience on the part of the observer to obtain all the useful information when using non-participant observation technique.
- It was difficult to observe how the calculations were being done as the system involved a lot of calculations so the technique cannot work in isolation. It is complimented by interviews, questionnaires and record inspection.

3.3 Analysis of Existing System

Analysis of the existing system is the study of the current system focusing on the systems' strengths and weaknesses as well as how to improve the system (Whitten *et al*, 1998). Current system weaknesses are also analysed and solutions to the weaknesses are vividly spelt out in the new system. Fact gathering techniques explained from on item **3.2 Information Gathering Techniques** are employed in the analysis of the existing system.

3.3.1 Description of Current System

The current Abnormal Load Advisory System is a completely manual system that ultimately see the production of abnormal load permit. There are some loads which by law are considered normal load. If a load is indivisible or when it is not economically feasible to break a load into smaller units for the sake of transporting the load then reassemble the load at its destination, then the load

can be moved from one point to the other as abnormal load. Such load need to be carefully loaded on the loading vehicle such that it does not damage the vehicle, road and bridges and road side furniture as well as posing danger to other road users. Transport operators as one of the system's stakeholders first have to register their trucks as abnormal load trucks. The truck combination, that is the horse and all its trailers are all registered as one unit. The vehicle's loading configurations are the data to be recorded on the abnormal load registration form called Application for Certification of Abnormal Vehicle Combination (ACA VC Form).

The data recorded is obtained from data plate found on every heavy load vehicle. The data plate is where the vehicle manufacturer give vehicle configuration specifications in terms of loading capabilities of the vehicle. After filling in the form, the vehicle combination is taken to VID for physical check where VID Inspector physically check to see if ACA VC form data correspond to the physical vehicle specifications. If the data on the form is different from the actual details on the vehicle, then the VID Inspector corrects the data recorded then certifies the application by signing and stamping the form to certify that the data recorded correspond to the vehicle configurations.

After certification of the VID Inspector gives the operator back the certified ACA VC form so that the operator can take it to DoR where the Bridges Technician/Engineer. Bridge Technician/Engineer then calculate the maximum ESWM for the whole combination, assign an Abnormal Vehicle Registration (AVR) number and prepare an invoice for registration fee. All this information is recorded on Advice For Certification for Abnormal Vehicle Abnormal Vehicle Certification in duplicate. This certificate serves to advice the operator on the capacity of loading of his/her Abnormal Vehicle Combination (AVC). After this the operator is issued with an invoice which the operator takes to ZINARA for payment as abnormal load registration fee. Abnormal registration is valid for twelve calendar months calculated from the day of registration.

ZINARA is the revenue collector of. Registration of Abnormal Load Vehicle is complete only after presentation of proof of payment of registration fee from ZINARA which is in form of ZINARA receipt. Registration process is completed by recording the receipt number and amount paid on the corresponding copy of the Advice For Certification for Abnormal Vehicle Abnormal Vehicle Certification which is filed in the abnormal load register file. Now that an operator has AVC registered, the vehicle is now allowed to move abnormal loads on Zimbabwe's roads but, an abnormal load permit has to be applied for each and every load.

Every time an operator is hired to move abnormal load on Zimbabwe's roads then a permit has to be applied for. Abnormal load permit application involves the operator making an application for the permit. The application is made on the Abnormal Load Application Form (ALAF). Several variables are recorded on the form by the operator including details of the load, source and destination of the load, proposed route of movement and the dates of movement. The DoR Bridges Technician/Engineer first checks to see if the operator and the AVC to be used is registered in the Abnormal Load Vehicle register. If the ACV is registered the permit application is considered otherwise the application is rejected. The ESWM of unladed AVC is checked from the register so as to see if the AVC has the capacity to move the load and if the operator is complying with the AVC's registration limits. The Bridges Technician/Engineer calculates the load's ESWM, tyre pressures, recommended travelling speed, permit fee which is directly proportional to distance from source to destination and advice on the route and dates of movement. All this recorded on the permit. Before the permit is issued, the Bridges Technician raises an invoice which again is taken to ZINARA for payment. Permit is issues after presentation of receipt from ZINARA. The permit expires within a short space of time, normally after a reasonable time enough to allow travel from source to destination. After the issuance of permit, the loaded AVC is taken to VID for physical inspection to see if the load is complying to the issued permit specifications. VID inspector then certifies the permit or rejects the permit if there is no compliance such that changes on the permit can be effected by either changing the AVC or reapplying for the permit.

3.3.1.1 Current System Inputs

System inputs involve variables required to be recorded for the processing of

- Operators details
- Vehicle load specifications
- Vehicle Registration number
- Combination configuration data
- Receipts from ZINARA

3.3.1.2 System Processes

- Registration of abnormal load vehicle combination
- Invoicing

- Route Determination
- Permit issuance
- Report production for management

3.3.1.3 System Outputs

- Abnormal load register
- Invoice
- Abnormal Load Permit
- Reports to management

3.4 Process Analysis

Process analysis is the sequential steps of a procedure that lead to the accomplishment of the procedure or the way a certain series of events occur (Norton and Waldman, 1992). There are two kinds of process analysis; namely directional and informational analysis. Directional process analysis also known as perspective process analysis tells of how a process is done. On the other hand informational also known as descriptive process analysis seeks to explain how something is accomplished or was accomplished (Norton and Waldman, 1992). So **Fig 3.1** is informational process analysis as it seeks to describe how to accomplish abnormal load registration and permit processing.

3.4.1 Activity Diagram of Current System

An activity diagram is a graphical representation that models computational and organisational processes and stepwise activities supporting iterations, choice and concurrency (Jaworski and Jaworski, 1986). Organisation's overall flow of control is shown by the activity diagram. Activity diagrams consist of activities, states and transitions between activities and states. According to Felici (2009) activity diagram describe the following facets:

- How activities are coordinated to provide a service
- Events required for an operation to be achieved
- How events in a single use case relate to one another
- How a collection of use case coordinate to create a workflow for an organisation.

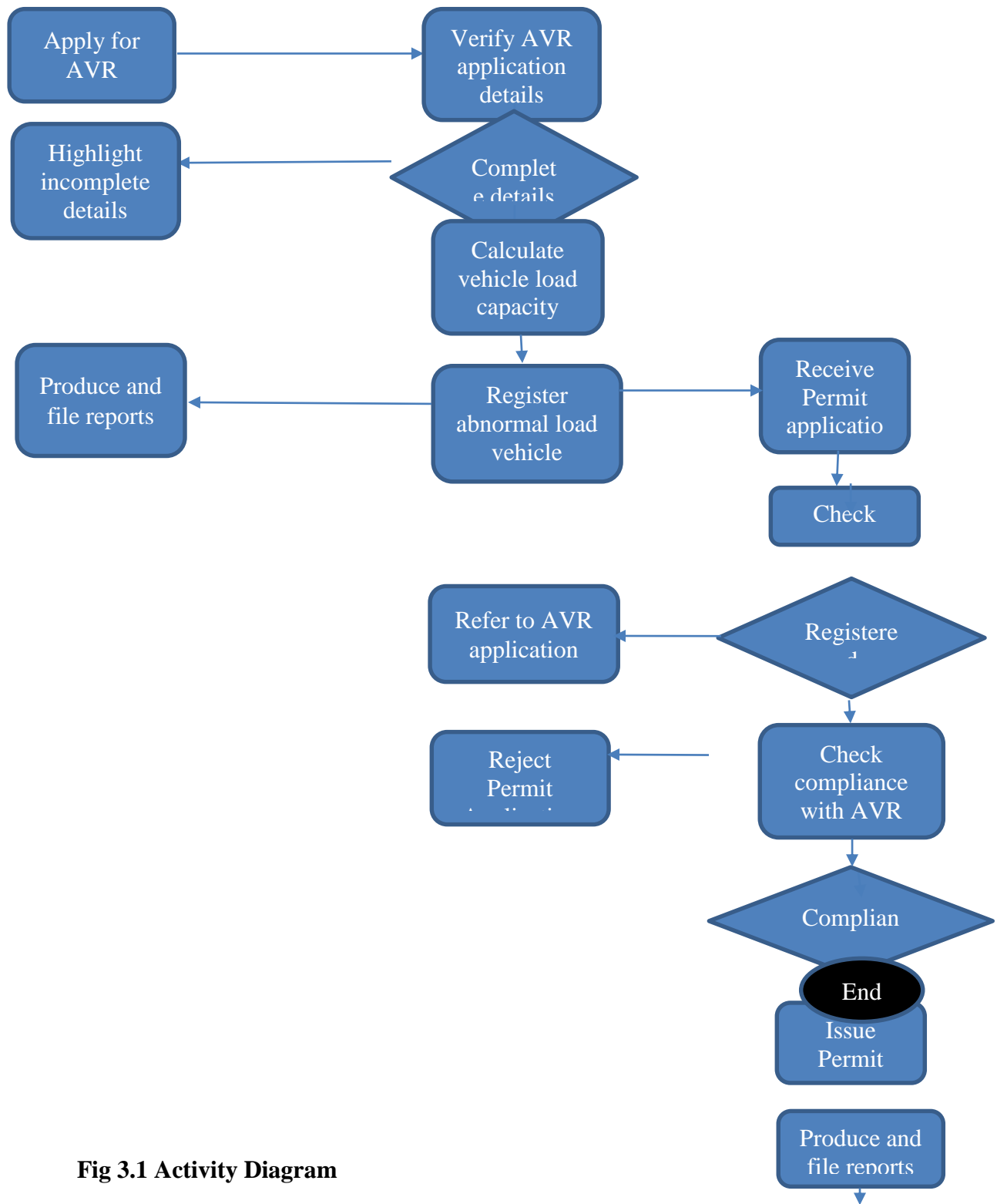


Fig 3.1 Activity Diagram

3.5 Data Analysis

Data analysis is a process that involves evaluating every data element, transforming, and modeling data so as to find useful information, suggesting conclusions, and supporting decision-making (Shelly and Rosenblatt, 2012). Data modelling is facilitated by the use of modelling tools such as data flow diagrams which makes it easier to illustrate the flow of data within the system.

3.5.1 Context Level DFD

A Data Flow Diagram (DFD) also referred to as process model is an illustration of the flow of data through a system and the work-or processing-performed by the system (Whitten et al, 1996). According to Whitten et al (1996) there are two alternative but equivalent set of symbols used and that is the Gane-Sarson or Yourdon symbol set. The set of symbol to be used is the Gane-Sarson. Context level DFD is an illustration that defines the scope and boundary for the system and the project (Whitten et al, 1996). Context level DFD depicts the “big picture” in terms of subsystems and functions. In other words it is the classic black box concept of systems theory (MacDonald in Whitten et al, 1996). So it shows the interaction of the Abnormal Load Advisory System with other entities in its environment as illustrated in **Fig 3.2 Context Level Data Flow Diagram**.

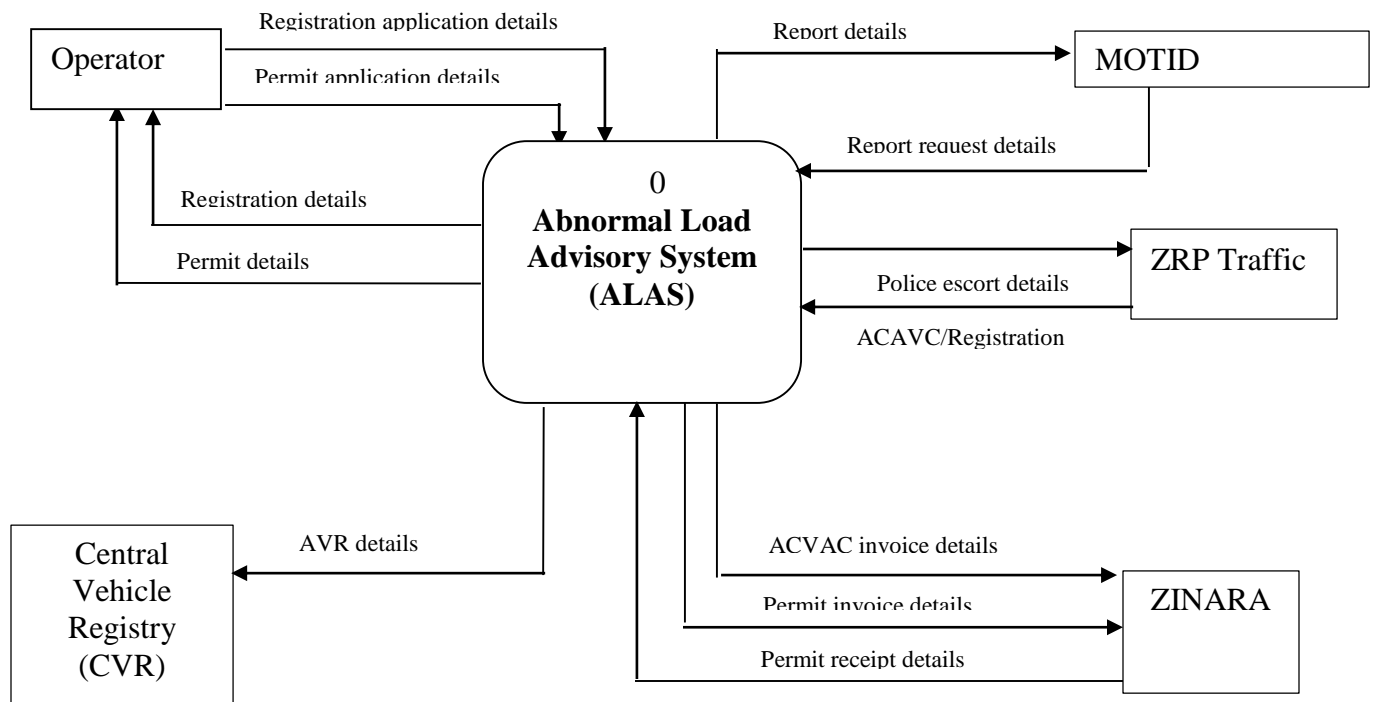


Fig 3.2 Context Level Data Flow Diagram

3.5.2 Data Flow Diagram

Data flow diagram (DFD) is a more detailed illustration derived from the context level DFD as it explodes the single process in context level DFD. “It provides a high level-view of the system that identifies the major processes and data store” (Donald, 2000). For simplicity, the DFDs are illustrated under three main processes namely Registration for abnormal load, Permit processing and report production process.

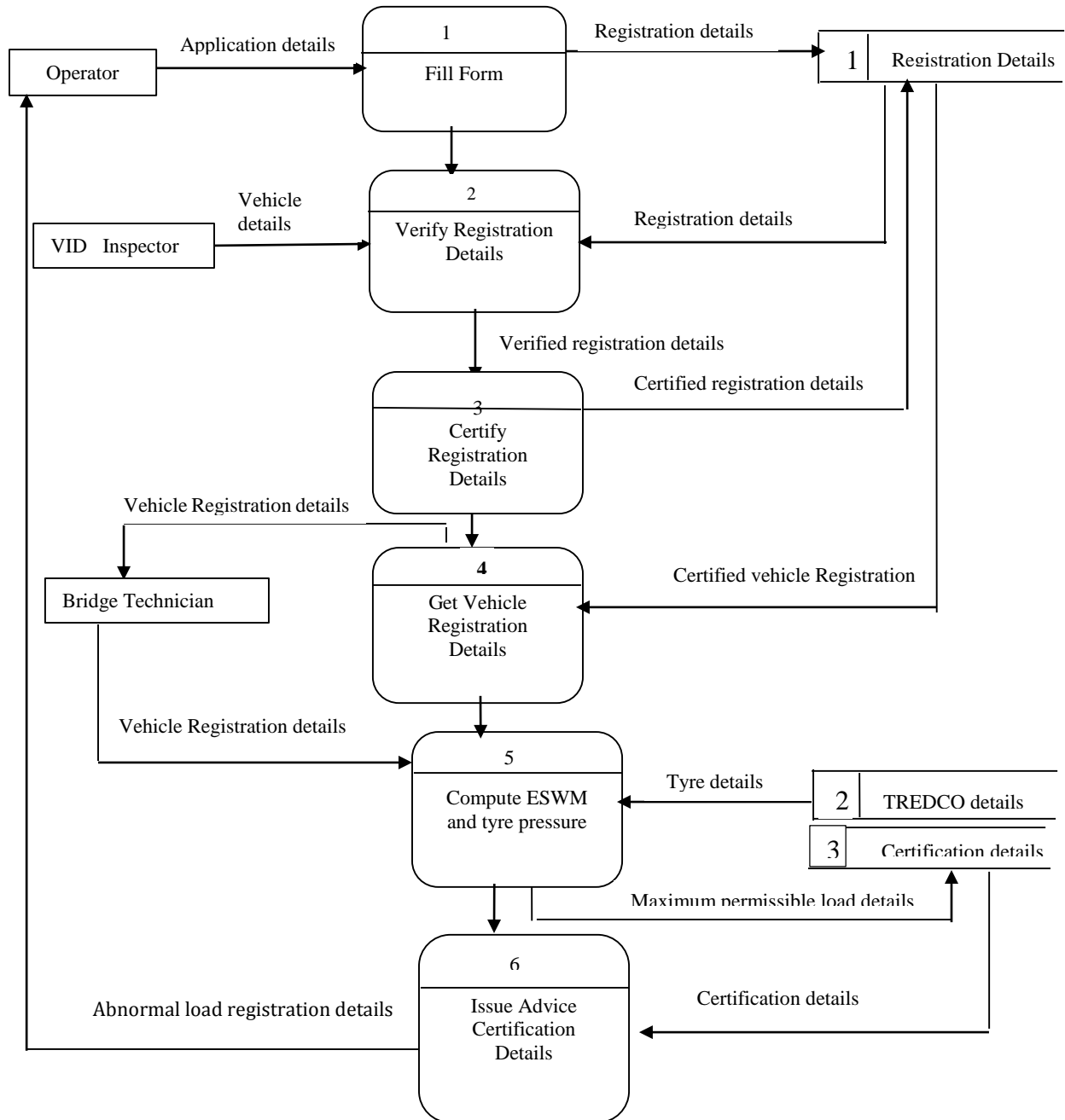


Fig 3.3 Registration Process DFD

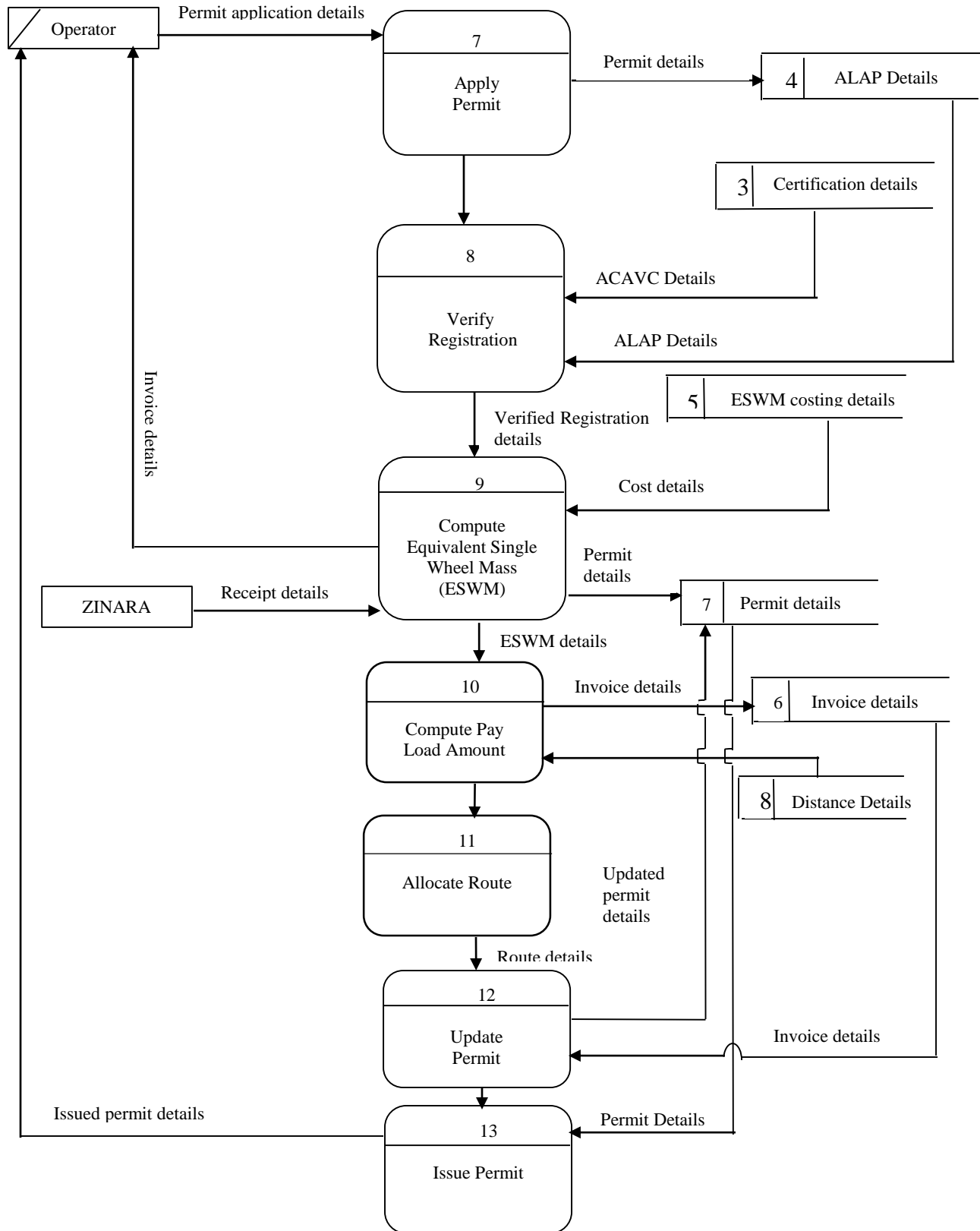


Fig 3.5: Report Production DFD

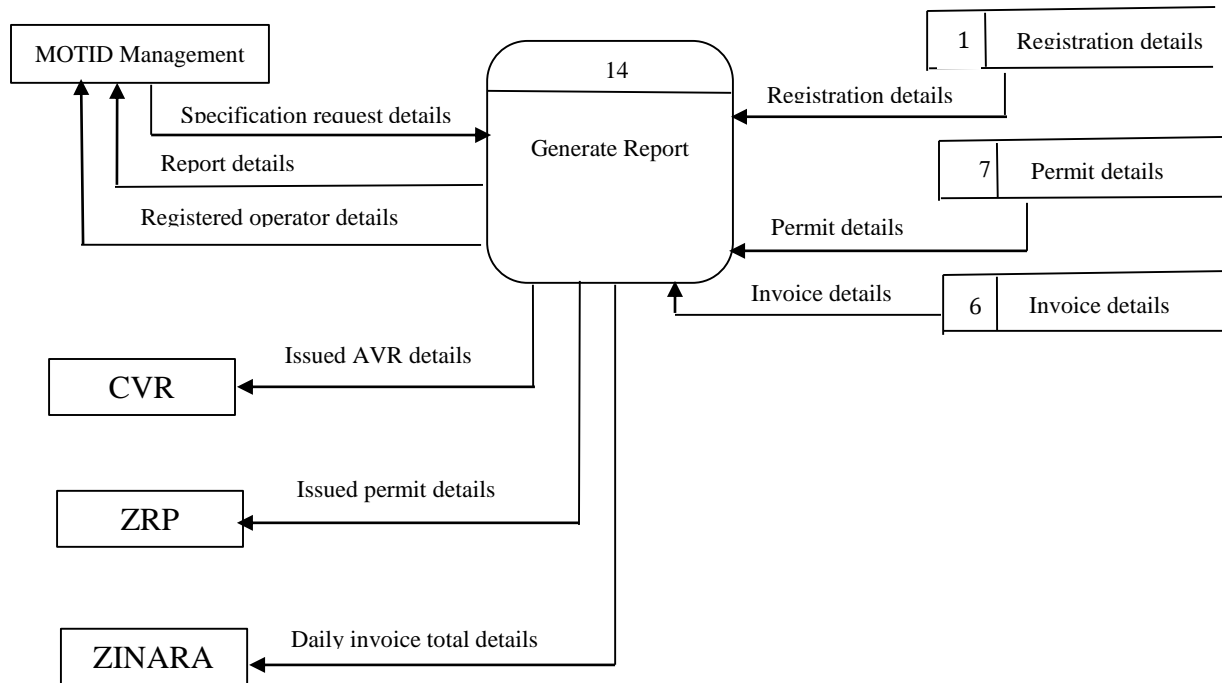
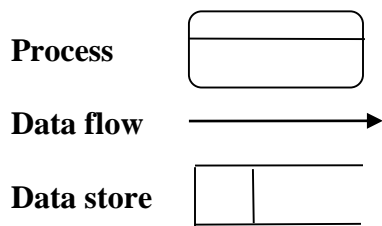


Fig 3.5 Report Production DFD

Key



3.6 Weaknesses of the Current System

- Registration of the abnormal load vehicles can only be done at the DoR head office in Harare, making it very expensive for abnormal load operators based outside Harare to register their vehicles as they have to travel from their offices to Harare to register their abnormal load vehicles.
- There is a lot of movement from one office to the other to complete the registration process as it involves moving from VID depots to DoR Head office, ZINARA offices for payment then back to DoR Head office to collect either ACAVC or Abnormal Load Permit.
- The minimum period for registration process to be completed is too long as it takes at least 7 working days for ACAVC to be produced.

- Abnormal load vehicle units such as horse, trailer and dolly cannot be registered as independent units but as the whole combination making it impossible to change a horse for instance suppose the original horse has a breakdown otherwise new registration.
- Calculation of ESWM, maximum travelling speed and route determination is so tedious and requires expertise which makes it susceptible to human error resulting in wrong calculations.
- The system is susceptible to fraud as the operator is made to move financial documents from one office to the other for example, the operator is the one who moves invoice from DoR to ZINARA for payment which the operator can alter, after all the invoice is written manually.
- It is not ease for DoR Bridges Technician/Engineer to search for a particular ACAVC from cabinet files when preparing a permit.
- The system lacks interaction required by ZIMASSET that a government should work like one unit. VID and DoR are departments in the same ministry using the same data when it comes to abnormal load operations but they work as if they are independent entities resulting in duplication of data.
- Unrestricted access to data files due to manual filing.
- Overloading the Bridge Technician/Engineer with more work as the system requires their expertise to be operational. In the absence of Bridges Technician/Engineer, there will not be any permits produced.
- The system is against one of ZIMASSET's key result areas (KRA) of automating all government business process, a KRA under the Infrastructure Development and Utilities cluster.

3.7 Evaluation of Alternatives

Evaluation of alternatives involves examination of considered options to solve the problems identified with the current system (Whitten *et al*, 1996). It is from the alternative solutions examined that a solution is chosen based on its suitability when compared to other alternative solutions considered. Alternative solutions considered were as follows:

- Improving the current system
- Outsourcing

- In-house development

3.7.1 Improving the current system

Improving the current system involves identifying the weaknesses of the current system then apply patches to alleviate the current problem but maintaining the current manual ALAS. An example would be training of more staff to carry out all the operations involved in ALAS thereby solving the current system weakness of lack of adequate staff to carry out all the operations involved. This would make the system be more efficient as abnormal load permits can be issued at all times even during the absence of Bridges Technician or Bridges Engineer as it is with the current system.

3.7.1.2 Advantages

- Relatively low costs involved
- There is not much changes involved such that operations will continue in the way the staff is familiar with.

3.7.1.3 Disadvantages

- The system remains manual which makes it incompatible with abnormal load advisory system of neighbouring countries in the region especially South Africa.
- Spot checks will still be impossible as it is difficult to move around with the vehicle registration file on the roads for spot checks.
- The problem of inconsistency due to lack of standards will not go as people use different approach to calculation of ESWM.

3.7.2 Outsourcing

Outsourcing involves the purchasing of already made software from an outside vendor rather than developing the system within the organisation, which is called in sourcing (Horngren *et al*, 1999). The purchased software at times does meet the exact organisational needs. So the software is customised by the supplier or organisation's programmers to meet the organisational needs depending on the contractual arrangements between supplier and purchaser. MOTID will incur costs in terms of training of staff and licensing of the software as such software is usually licensed.

3.7.2.1 Advantages

- Avails an instant solution to the current problem.

- Maintenance of the system is the responsibility of the developing organisation so less work for the organisation
- The software purchased is a tried and tested software thereby giving a low failure rate

3.7.2.2 Disadvantages

- MOTID does not have total control of the software as the software does not wholly belong to MOTID.
- Security is compromised as the software supplier has to gain an insight into the internal business process of MOTID so as to customise the system.
- Difficult to maintain as consistent reference is made to the supplier.

3.7.3 In-House Development

In-house development is building of the Abnormal Load Advisory System by MOTID staff. This is also referred to as in-sourcing (Tricker and Boland, 1999). MOTID makes use of its Systems Analyst and Programmers to develop the system. This will increase the MOTID staff technical and functional skills which they gain through development. Further, in-house development instill ownership of solution on employees. Alignment of the information system and organisational strategies would be made easier as the system is being developed by MOTID staff who know better the organisation's strategies. In-house development has a high initial cost but the cost reduces in the long run as system improvements are done through maintenance. Also in-house development addresses all the weaknesses identified with the current system and as such this in-house development approach was chosen as the best approach in solving the current system problems.

3.7.3.1 Advantages

- Security risk is reduced as information leakage is relatively when compared to outsourcing
- User needs are relatively quickly understood as the developers are also part of the current system hence they have first-hand experience with the current system problems.
- It is cost effective as has been highlighted earlier on in the feasibility study.
- The system is wholly owned by the organisation and as such total control of the system is wholly with the organisation.
- It promotes one of the goals of ZIMASSET on e-government that is computerising government business processes.

- It promotes innovation especially in the field of information technology as the developing team is from MOTID staff who get to acquire new ideas through the ALAS study.
- Alignment of the information system to the business strategy is made easier through in-house development as the system is developed by MOTID staff who know better the organisational business strategies.

3.7.3.4 Disadvantages

- Long standing differences among staff may compromise on the quality of the system
- Organisational politics may get in the way of progress of the system being developed.
- Prioritisation of other projects such as road construction resulting in all the finances being directed to the project with higher priority.

Analysing each alternative solution shows that more benefits are coming from in-house development thereby making it the option of choice to address the problems with the current system. Furthermore, in-house development is in full support of the ZIMASSET and MOTID as a government ministry is compelled to choose in-house development.

Cost Description	Alternative		
	Outsourcing	Improvement of Existing System	In-house Development
Acquiring Software	\$10 000.00	-	-
Development	-	\$1000.00	\$2000.00
Training	\$2000.00	\$100.00	\$400.00
Maintenance	\$900.00	\$400.00	\$400.00
Stationery	-	\$3000.00	\$600.00
TOTAL COST	\$12 900.00	\$4500.00	\$3600.00

Table 3.1: Cost based Justification

Table 3.1: Cost based Justification shows that In-house development is the favourable choice among other alternatives as it involves the least costs.

3.8 Requirements Analysis

Requirements analysis defines what the system must be capable of (functional) or properties of that system (non-functional) that meet user needs to perform specific tasks within a defined scope

(miter.inc, 2015). The main intention of requirements analysis is to outline in precise, complete and unambiguous manner to what the system must do to meet the exact user needs. A thorough requirements analysis reduces corrective efforts in future. Requirement analysis has two subdivisions which are functional and non-functional requirements.

3.8.1 Functional Requirements

Functional requirements of a system is what defines the function of a system which is described by the set of inputs, behaviour and outputs of the system (Rechtin, 1992). There are system specification functions that the system must support such that their absence is tantamount to system being defunct. The necessary specification functions are:

- The system must be secure such that only authorised users have access to the system through the use of unique password for each and every user.
- Different system users must have different access levels so that each user has access to data concerning his/her areas of interest.
- System must be able to provide for comprehensive reports to management such that informed decisions can be made pertaining to road maintenance planning.
- The system must be able to analyse the most frequently used routes.
The system must be able to pick all registered units of abnormal vehicle combination so that a single unit like horse, trailer, and dolly can be used with any other registered units to make a combination rather than being tied to one combination.
- The system must allow multi users to use the system concurrently.
- The system must be able to provide for instant access to data at all times.
- Up-to-date reports must be generated at any given time

3.8.1.1 Use case diagram

A use case diagram is a graphical representation of the interaction between the system and its users (Rechtin, 1991). A complete use case diagram depicts deferent ways of using the system without showing the internal structure of the system.

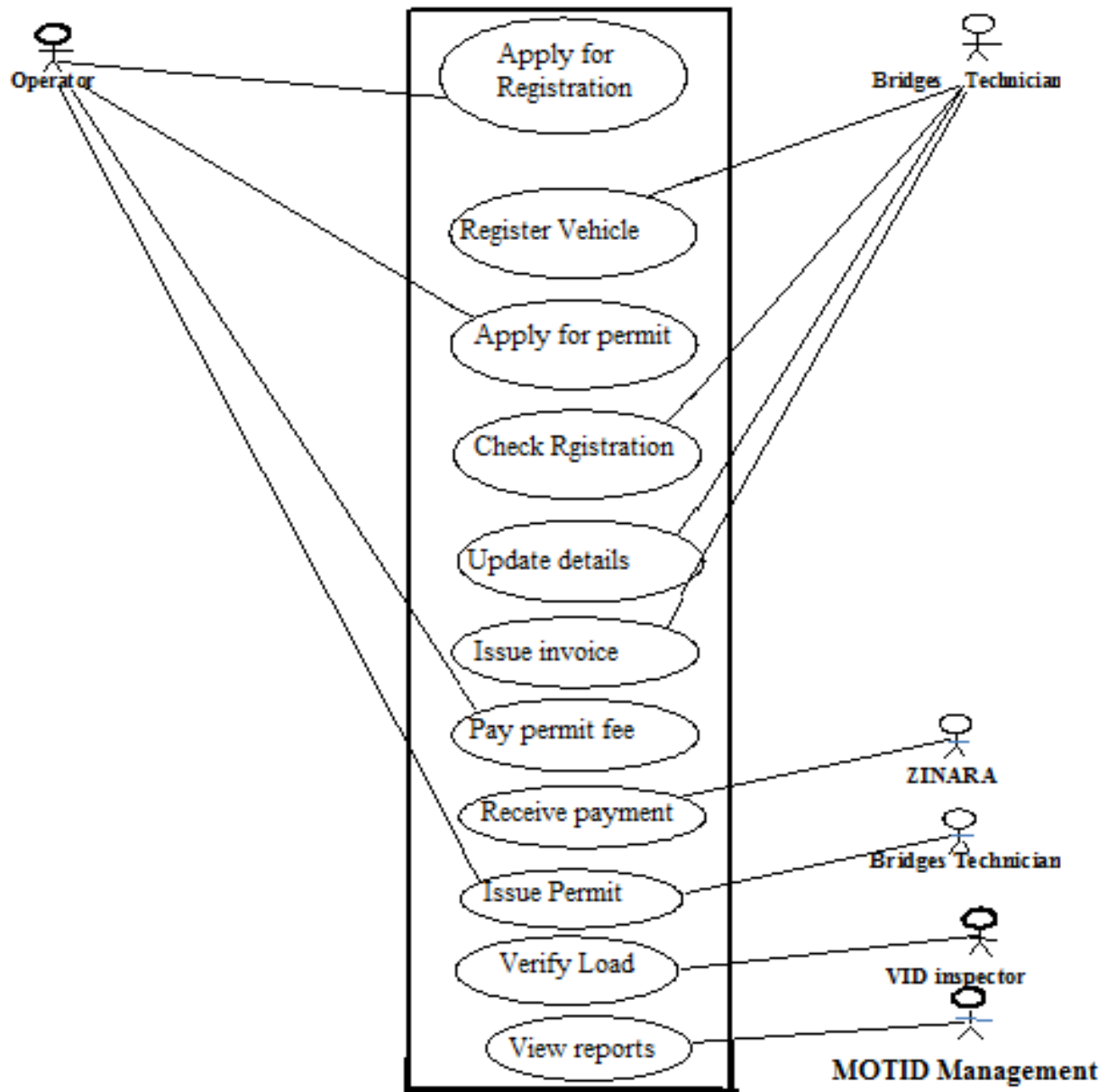




Figure 3.6: Use Case Diagram

Key

Description	Symbol
Actor	
Process	

3.8.2 Non Functional Requirements

Non-functional requirements are properties of the system that is characteristics and constrains that define a complete system inclined to security, response time, performance and ease of use. Non-functional requirements of the system culminate in the following characteristics of and features of the system:

- The system should be user friendly and easy to understand
- The system should be easy to input and retrieve information.
- The system should provide for system recovery and back-up facilities so as to avoid loss of data.
- The system must have interactive user interfaces that are professional.
- Log in credentials should include a password to secure the system from unauthorised entry.
- The system should validate input data so as to uphold data consistence.

3.9 Conclusion

After the in depth study of the current system and an evaluation of alternative solutions to the problems with the system, a conclusion was reached that developing a computerised system is the best among the identified alternatives. The weaknesses of the current system have been explored as well as the new system's requirements such that the next chapter, Chapter 4: Design, focuses on putting the requirements of the new system in place. In other words, design dwells on the logical design of the new system.

CHAPTER 4: DESIGN PHASE

4.1 Introduction

The design phase focuses on how the proposed system is going to work and how it is going to be constructed or designed. After analysing the logical requirements, physical, architecture, interface, database and program designs; physical design is outlined. All the designing of the new system is outlined at the design phase. The main deliverable of the phase is the technical design which is mostly used by the development team. System Design Document marks the transition from Business Requirements Report to Technical Design Document. Design phase entails choosing the tasks that are to be performed by computer, designing human procedures to fit around computer tasks, designing forms to collect and summarise data, choosing the correct pieces of hardware, designing tests and fault finding routine (Jaworski and Jaworski, 1986). The phase does not involve so much of client business and as such this is the opportunity to provide for high-level appearance and operations of the applications (Mochal and Mochal, 2003).

4.2 System Design

System design involves formulating and explicitly highlighting basic functionality of the system to be developed thereby showing how the system would work (Weaver, Lambrou and Walkley, 2002). A well designed system is characterised by efficiency, effectiveness, reliability, maintainability and security.

4.2.1 Efficiency

Efficiency is the ability to produce the required product with minimum effort. In other words, efficiency means doing the thing right (Aubyn, Pina, Gracia, and Pais 2009:5). The system should run operations in the least expected time thus it should be fast. There should be a smooth flow of processes reducing the amount of time taken to complete processes.

4.2.2 Effectiveness

Effectiveness refers to the capability of the system to produce desired results thus the intended outcome will be realised (Sumner, 2003). The system should produce the right product as argued by Aubyn *et al* (2009) that it should do the right thing. Doing the right thing can be measured from the results that come out. So effectiveness of the ALAS can be measured from the system's deliverables.

4.2.3 Reliability

Reliability refers to the ability of the system to perform its intended operations in a real environment without experiencing failures or recovery is straight forward when failure is experienced (Hughes and Cotterell, 2006). The system should be capable of producing timely reports so that decision making is done in time. A reliable system is one which is able to quickly recover from errors thus reduced down time. Furthermore the system should be accurate and provide verifiable information.

4.2.4 Security

Security refers to privacy and confidentiality to system information and data resources. Security constitutes protection of data from unauthorised disclosure, alteration, or destruction (Everest, 2001). Also included in security is access control which seeks to prevent unauthorised access and update including destruction. Information and data need to be protected from potential threats which include:

- Deliberate threats:- these include theft of hardware and software. Also included is abuse of passwords. So hardware should be kept under lock and key to restrict access.
- Accidental threats:- These comprise of accidental deletion of data or unintentional alteration of data resulting in loss of data or loss of meaning respectively. Security feature to counter such threats is to maintain a backup that is constantly updated.
- Natural threats:- Natural threats comprises of natural disasters such as floods, earthquakes, volcanoes and fires. Natural disasters are uncontrollable.
- Viruses:- Computer virus is a piece of code that copies itself into one or more larger host programs when it is activated. The sole intention is to disrupt the normal running of the host program such that it does not work normally (Spafford, 1994:2). To guard against viruses, anti-virus software must be installed on computers so that viruses are detected and cleaned away before harm is caused.

4.2.5 Maintainability

Maintainability entails being able to adapt to changing environment. The continual changing if information system environment calls for modifications of the system, therefore the system should always leave room for such changes thus maintainability (Hughes and Cotterel, 2006). It should

be easy to make changes to the system whenever the environment changes in response to changing environment.

4.3 Description of Proposed System

Proposed system description highlights the packages involved, inputs, processes and outputs as how the system works is outlined. The new system will:

- Capture and store abnormal load operator's details and vehicle loading configuration attributes.
- Register abnormal load vehicle combination which abnormal load vehicle operators would have made application for.
- Allocate abnormal vehicle registration number (AVR) unique to each vehicle combination for identification purposes.
- Determine the maximum permissible axle loading of the vehicle combination that is the maximum gross combination mass (GCM) that the vehicle should never exceed to facilitate safety on the roads.
- Calculate the equivalent single wheel mass (ESWM) of the whole vehicle so as to help on how to distribute load mass when loading the vehicle.
- Generate advice for abnormal load certificate.
- Process permit application when operator applies for permission to move goods weighing more than the 56 000 Kgs; the normal regulation stipulation.
- Determine if the permit being applied for is in compliance to what the vehicle is capable of loading in terms of mass.
- Calculate the pay load amount and generate an invoice depending on the distance to be travelled by the load.
- Determine the route to be used when moving the load from its source to destination.
- Generate abnormal load permit.
- ALAS will generate reports in different dimensions which include permits issued per given period, most frequent routes, statistical data of the loads being moved, registered vehicles summaries.

4.3.1 Context Level DFD for Abnormal Load Advisory System

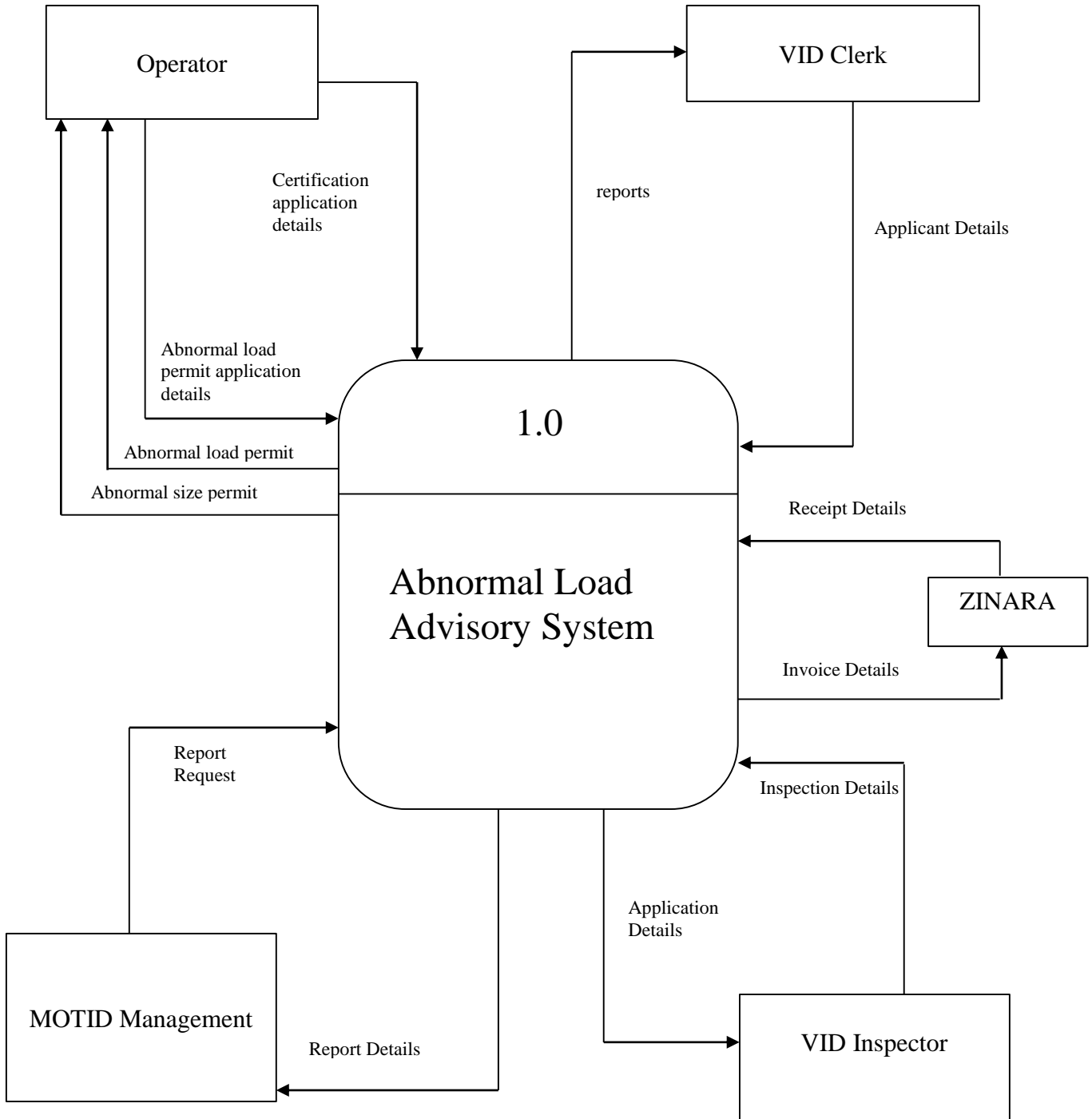


Figure 4.1: Context diagram for Abnormal Load Advisory System

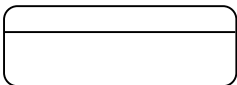


SYMBOL	DESCRIPTION
	System
	Entity
	Data flow

Table 4.1: Key for the Context diagram

4.3.2 Proposed System Data Flow Diagram

Data flow diagram is a graphical presentation of flow of information through the system and between the system and its environment including the functions that the ALAS must perform (McMullan, 2009). DFD show the actual processes involved in transforming and or manipulate data stored in the ALAS. All the necessary processes are shown as they transform data into useful information through the DFDs. Data flow complexities are eliminated in the proposed system as it has one data repository unlike the current system which has many data repositories making data flow very complicated hence redundant data. Having one repository entails reduction in data redundancy. To simplify the presentation of the DFDs, the DFD has been split into three main processes which are Application for Abnormal Load Certification, Application for Abnormal Load Permit (AALP) and Reports DFD. Table 4.2 shows the DFD symbol notations used in all DFDs.

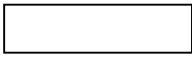
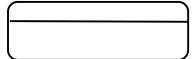
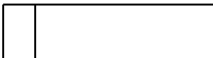
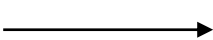
SYMBOL	DESCRIPTION
	Entity
	Process
	Data store
	Data Flow

Table 4.2: Key for the data flow diagrams

4.3.3 Data Flow Diagram for Application for Certification of Abnormal Vehicle (ACAV)

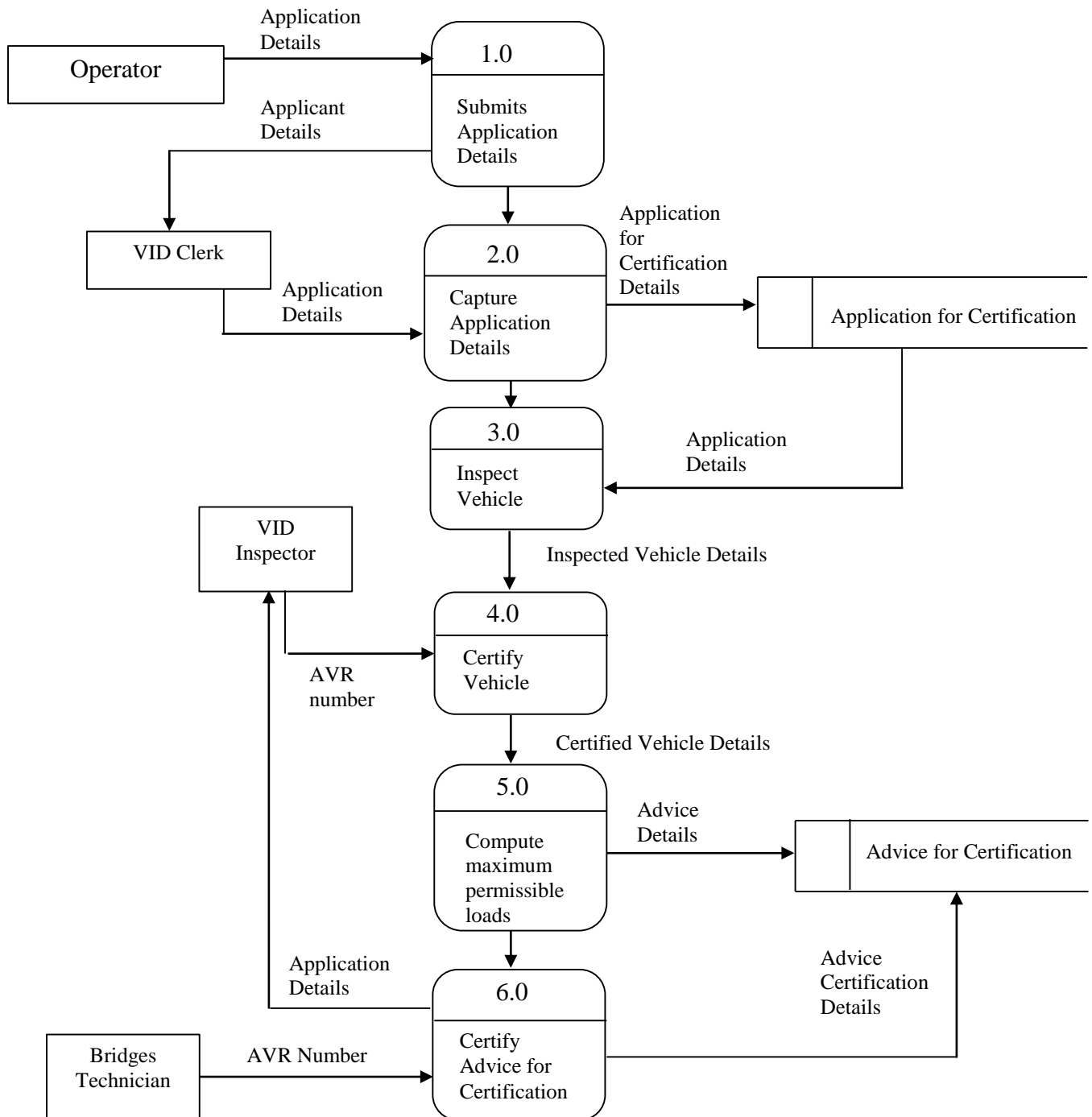


Figure 4.2: Data Flow Diagram for Application for Certification of Abnormal Vehicle

4.2.4 Data Flow Diagram for Application for Abnormal Load Permit (AALP)

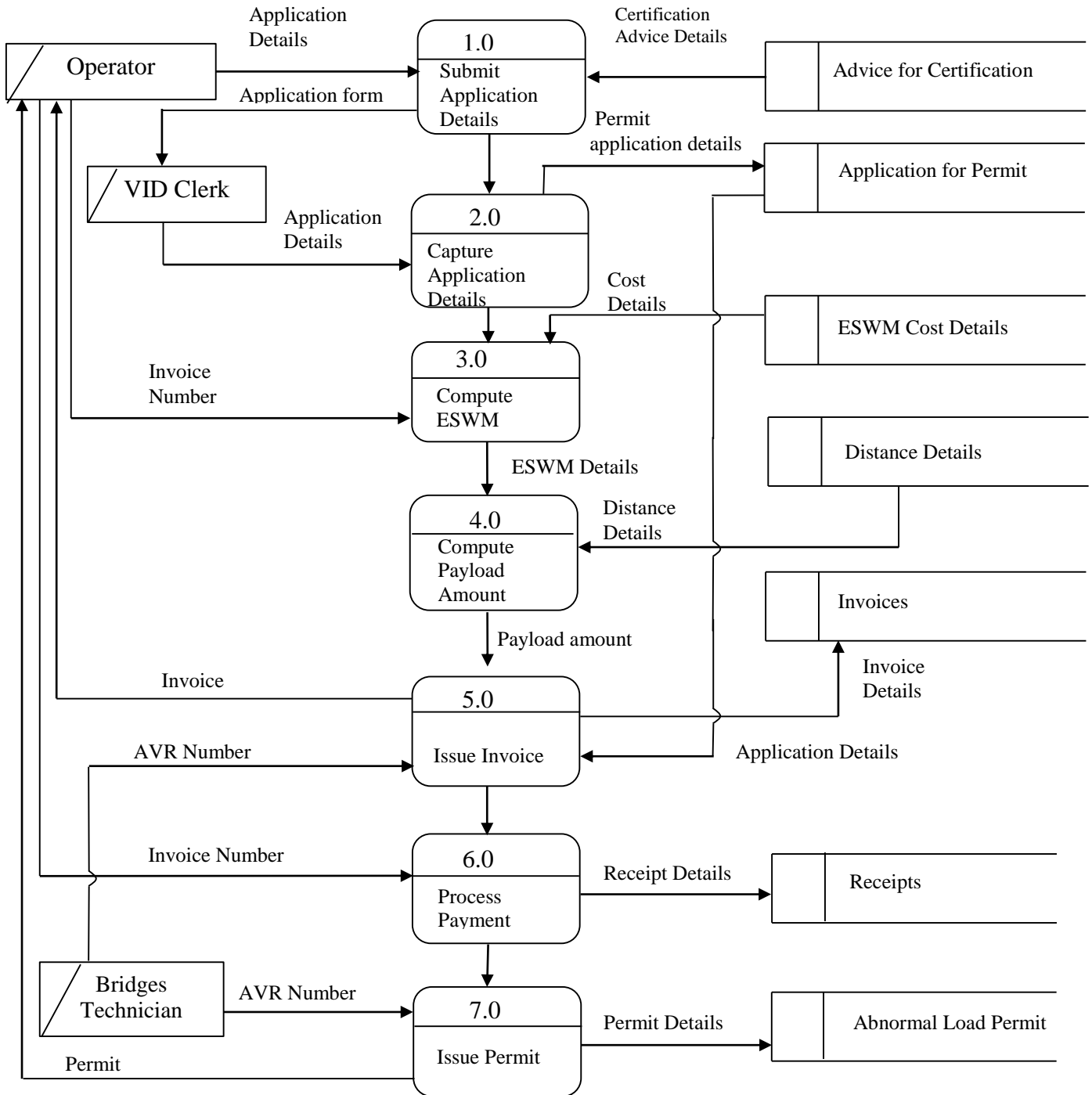


Figure 4.3: Data Flow Diagram for Application for Abnormal Load Permit

4.2.5 Data Flow Diagram for Reports

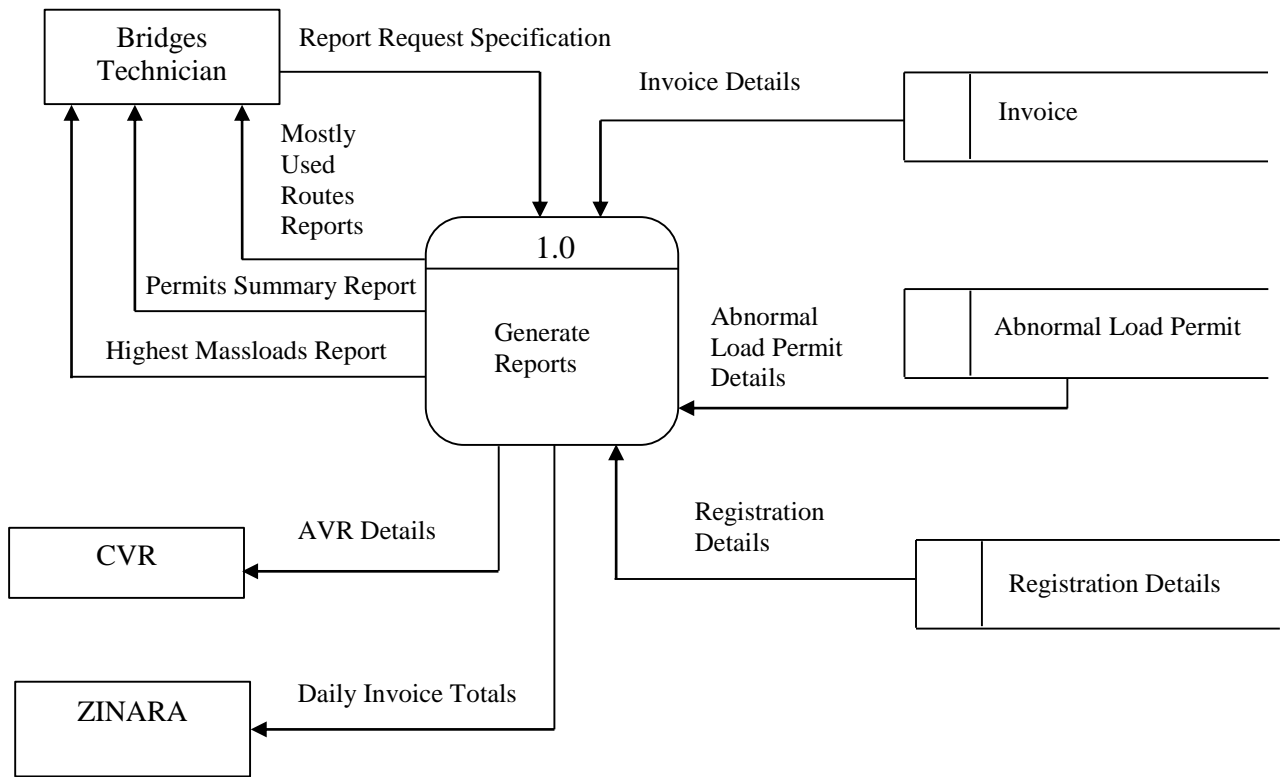


Figure 4.4: Data Flow Diagram for Reports

Key

SYMBOL	DESCRIPTION
	Entity
	Process
	Data store
	Data Flow

Table 4.3: Key for the data flow diagrams

4.4 Architectural Design

Architectural design is the translation of logical model into specific technical model (Whitten *et al*, 1996). It entails the software and hardware design on which the new system is going to operate on. The new system will be a client-server architecture which according to Sommerville (2001) is an architecture that uses a central computer named server that stores all the resources used by other work-stations on the network information as a resource also included. The work stations on the network are the clients to the central computer from which the client request resources and services according to pre-defined user access rights (Forouzan and Fegan, 2007). The system will be web-based.

a.) Client Computer or Workstation

These are terminals on the network which are connected to the central computer/server. The terminals have different access levels to the database depending on the user who would have logged on through the system. System users can edit, upload or manipulate data on the central server from the client computers as well as generate reports.

b.) Central Server

Central server is the residence of all the data used by ALAS. All the requests made by client computers are handled by the central server. Requests from clients are made through the web browser from client computers connected to the server. Wamp web-server will then search for the requested page then communicate with MySQL which has the responsibility of bringing the page to the client web browser. Access to the resources on the server are limited to authorized users.

c.) Printer

Printers shall be connected to the server for printing Advice for Abnormal Load Certificate, Abnormal Load Permit and management reports. Again this facility is limited to authorized users on the network.

4.4.1 Proposed System Architecture

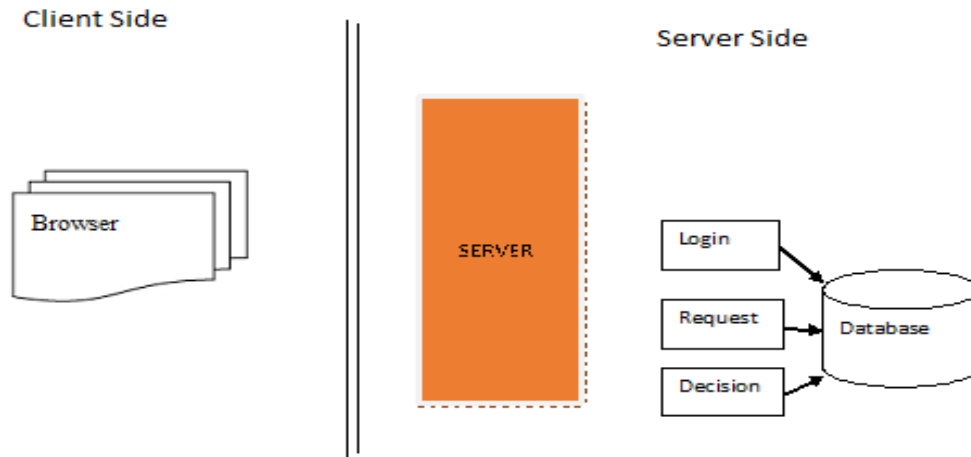


Figure 4.4: Proposed System Architecture

Source: (Mochal, 2008)

4.5 Physical Design

Physical design focuses on the technical environment of the proposed system that is translation of abstract logical model into specific technical design (Jaworski and Jaworski, 1986). This is where the interaction of software and hardware is shown. **Figure 4.5** depicts the entirety of the run-time system through identification of the way various code components are distributed across the platform.

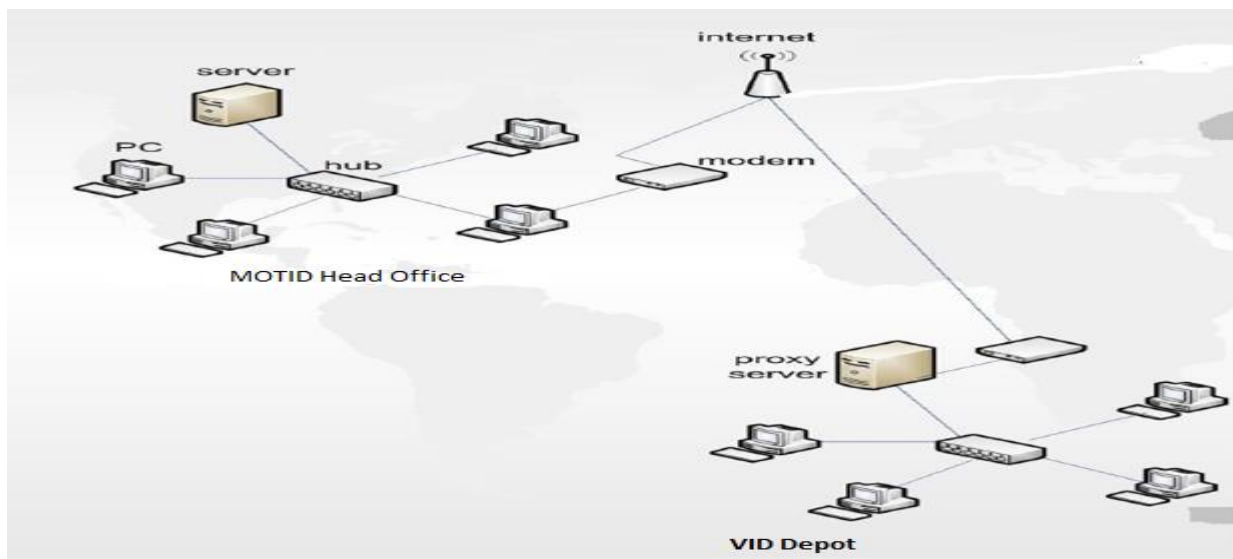


Figure 4.5: Physical Design of Proposed ALAS

Source: (Donald, 2000)

4.6 Database Design

Database design is the process of designing physical and logical structure of tables to accommodate organizational information needs for the ease of users (Sommerville, 2001) This is where every entity whose information the system needs is unveiled. A good database is characterized by data consistency, integrity and minimal redundancy.

4.6.1 Database Architecture

Database architecture is the logical representation of the database. The database basic schema is depicted here as well as showing how different users access the database at different access levels (Yeates and Cadle, 1996). Database architecture is composed of three layers which are external, conceptual/community and the internal layer (Gamper, 2008).

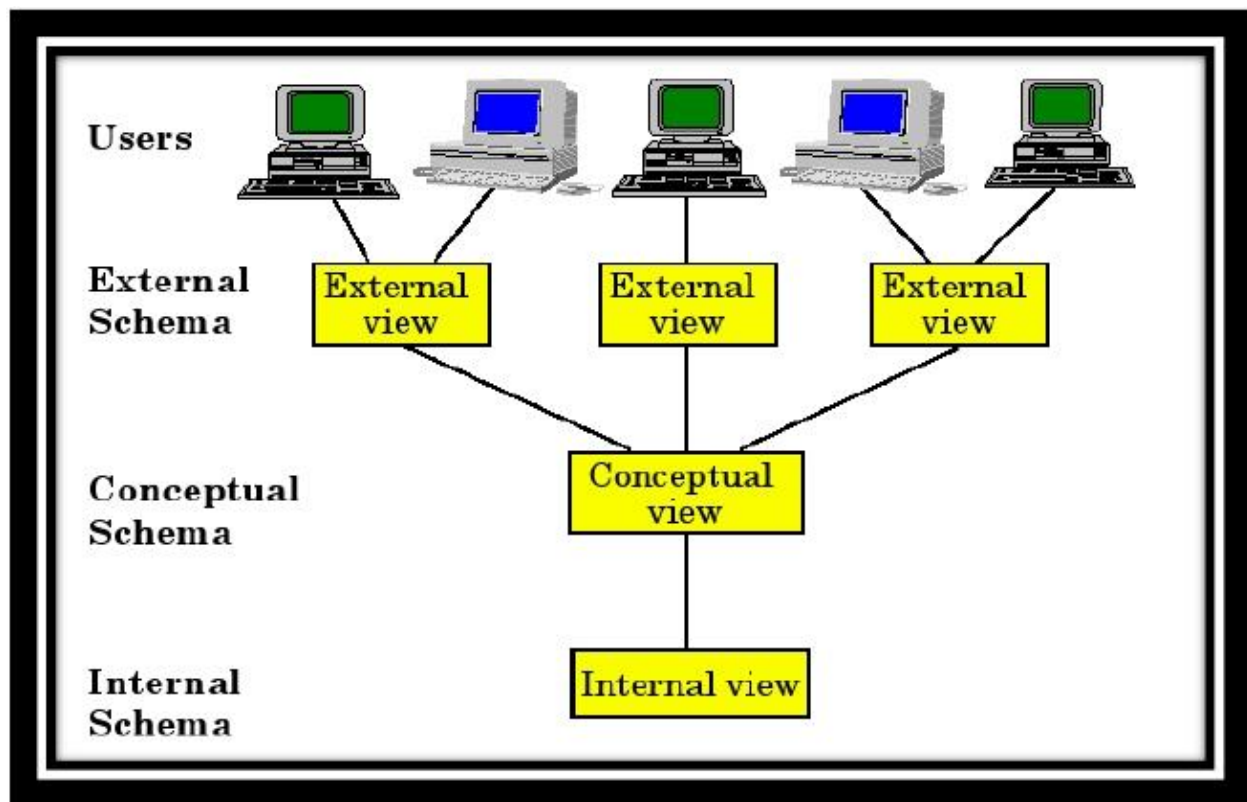


Figure 4.6: Architectural Design

(Source: Gamper, 2008)

a.) External Schema

External schema is the highest level abstraction of database design (Everest, 2001). External schema serves the purpose of simplifying user's interaction with the database as it provides for interface between user and database. User's view is tailored to suit the user's needs such that interaction with the database is made easy to the user (Sumner, 2003). Users can only view data that is only relevant to them through forms, tables or reports.

b.) Conceptual Level

Conceptual view sometimes referred to as community view. This level describes all the data stored in the database and the relationships that exist amongst the data. It is referred to as community view because this is where the field names, data types and all queries are defined for all the data of ALAS. Queries are defined at the conceptual levels including their relationships with the tables and data.

c.) Internal Level

This is the lowest level of abstraction defining how data is actually stored on the database server. It provides the concept that describe the data of how data (metadata) is stored in a computer. Physical attributes of the database are defined at this level which include record placement, indexing, compression and encryption techniques. The internal level is attached or connected to the physical database which is where data is actually stored. MySQL database is the software to be used to achieve this and it will be stored on the server database which will be administered by the Systems Manager of MOTID. Data normalization of all the data has to be carefully done into database relations.

4.6.1 Entity Relationship Diagram (ERD)

Entity Relationship Diagram (ERD) is a graphical data model representing elements at the conceptual level that depicts meanings and interrelationships between these elements independent of any Database Management System (DBMS) in a database (Rob and Coronel, 2002). ERDs show database main components which are entities, relationships and attributes. According to Rob and Coronel (2002) each component is represented by standard notations. It is important to identify all

the entities and attributes pertaining to each entity before drawing the ERD because a meaningful ERD includes all the entities (Date, 2005).

Identification of Entities and Attributes

An entity is an object of interest to the business and every entity has properties that describe the entity which are referred to as attributes (Whitten *et al*, 1996). In identification of entities, firstly data objects that are going to be stored need to be identified then identify the relationships that exist between the data object. This is so as to establish how the entities interact to make up the Abnormal Load Advisory System. Entities and attributes of ALAS are shown in **Table 4.4: Entities and Attributes of ALAS.**

Entity	Attributes
Operator	id, name, company name, address
VID Clerk	Id, name, surname, username, password, branch
Bridges Technician	Id, name, surname, username, password, branch
VID Inspector	Id, name, surname, username, password, branch
Application for Certification	Id, vehicle_id, vehicle_dim_id
Application for Permit	Id, date, Avr_no
Vehicle	Reg_no, make, model
Permit	Id, issue_date, valid_until
Advice Certificate	Avr_no, issue_date, valid_until

Table 4.4: Entities and Attributes of ALAS

Enhanced Entity Relationship Diagram

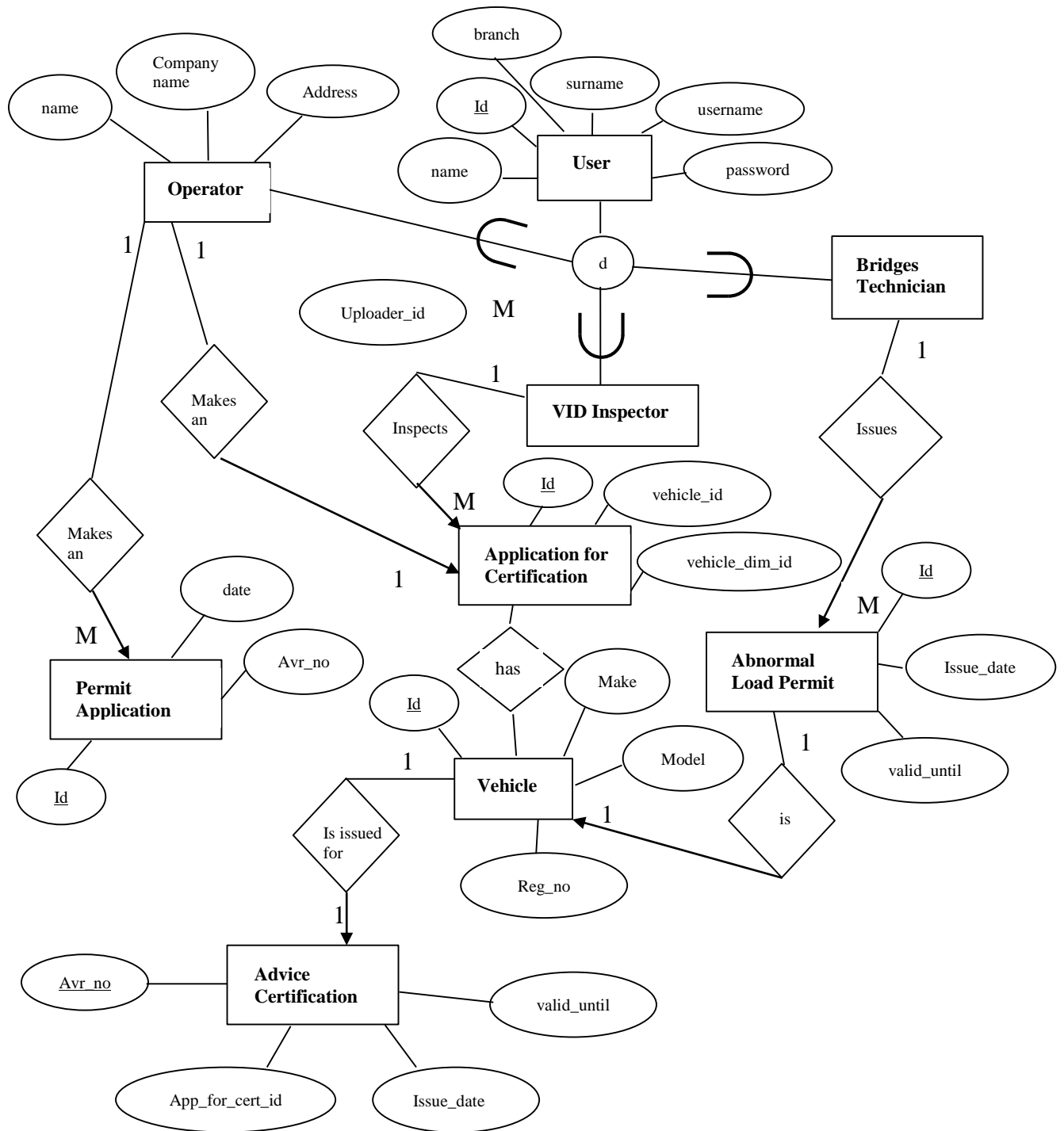


Figure 4.7: Enhanced Entity Relationship diagram for Abnormal Load Advisory System

Key






Symbol	Description
	Entity
	Attribute
	Relationship
	Disjoint Union
	Union

Table 4.5: Key for Enhanced Entity Relationship Diagram

4.6.2 Data Dictionary

Data dictionary, sometimes referred to as metadata repository is a repository that stores information about data facts such as data format, field size, meaning, origin, usage and relationships to other data (Everest, 2001). The actual data is stored in tables which are database elements. Details about the entities on the ERD are further described in the data dictionary thus meta data such as **Table 4.6**

Operator/Applicant

Column	Data Type	Description
id	Integer	Applicant Identification Number
Name	Variable Character	Applicant's name
Surname	Variable Character	Applicant's surname
Address	Variable Character	Applicant's address

Table 4.6: Operator/Applicant

Advice for Certification of Abnormal Vehicle (ACAV)

Column	Data type	Description
id	Integer	Advice for Certification ID Number
App_id	Integer	Foreign Key (Application for Certification Table)
Avr_no	Integer	AVR Number
Max_mass_load_id	Integer	Foreign Key (Maximum mass load table)
Max_mass_load_speed_id	Integer	Foreign Key (Maximum mass load speeds table)

Table 4.7: Advice for Certification of Abnormal Vehicle (ACAV)

Application for Certification of abnormal vehicle combination (ACAVC)

Column	Data Type	Description
id	Integer	Application Identification Number
avr	Integer	AVR Number
Applicant_id	Integer	Applicant ID (Foreign Key)
Vehicle_id	Integer	Vehicle ID (Foreign Key)
Vehicle_dim_id	Integer	Vehicle Dimension ID (Foreign Key)
Vehicle_config_id	Integer	Vehicle Configuration ID (Foreign Key)
Vehicle_comb_id	Integer	Vehicle Combination ID (Foreign Key)

Table 4.8: Application for Certification of abnormal vehicle combination (ACAVC)**Abnormal Load Permit**

Column	Data Type	Description
id	Integer	Permit Identification Number
date	Date	Permit date of issue
Valid_until	Date	Permit Expiration Date
Permit_app_id	Integer	Foreign Key (Permit application ID)
Receipt_no	Integer	Receipt Number
Cold_inflation_tyre_p_steer	Integer	Cold inflation Tyre pressure steer wheels
Cold_inflation_tyre_p_drive	Integer	Cold inflation Tyre pressure drive wheels
Cold_inflation_tyre_p_dolly	Integer	Cold inflation Tyre pressure dolly wheels
Cold_inflation_tyre_p_trailer	Integer	Cold inflation Tyre pressure trailer wheels
Max_speed_urban	Integer	Maximum permitted speed for urban
Max_speed_rural	Integer	Maximum permitted speed for rural
Max_speed_over_bridges	Integer	Maximum permitted speed over bridges
Standard_permit_conditions	Variable Character	Standard Permit Conditions
Escort_requirements	Variable Character	Escort Requirements
Type_of_permit	Text	Type of permit (single trip or period)

Table 4.9: Abnormal Load Permit**Invoices**

Column	Data Type	Description
id	Integer	Invoice ID Number
date	Date	Date of invoice
Avr_no	Integer	Abnormal Vehicle Registration Number
amount	Decimal(10,2)	Invoice amount

Table 4.10: Invoices

Receipt

Column	Data type	Description
id	Integer	Receipt ID Number
Invoice_no	Integer	Invoice Number (Foreign Key)
Receipt_no	Integer	Receipt Number (From Zinara)

Table 4.11: Receipt

Vehicle Details

Column	Data Type	Description
id	Integer	Vehicle Identification Number
Truck_reg_no	Variable Character	Truck Identification Number
make	Variable Character	Truck make
model	Variable Character	Truck Model
Net_mass	Integer	Truck Net Mass
mgcm	Integer	Truck Maximum Gross Combination Mass
mgvm	Integer	Truck Maximum Gross Vehicle Mass
Front_axle_rating	Integer	Front Axle Rating
Rear_axle_rating	Integer	Rear Axle Rating
Engine_make	Variable Character	Engine make
Engine_model	Variable Character	Engine Model
Power_at_clutch	Integer	Power at Clutch
Trailer_reg_no	Variable Character	Trailer Registration Number
Trailer_make	Variable Character	Trailer Make
Trailer_net_mass	Integer	Trailer Net Mass
Trailer_mgvm	Integer	Trailer Maximum Gross Vehicle Mass
Trailer_axle_rating	Integer	Trailer Axle Rating
Kingpin_rating	Integer	Kingpin Rating
Dolly_reg_no	Variable Character	Dolly registration Number
Dolly_make	Variable Character	Dolly Make
Dolly_axle_rating	Integer	Dolly Axle Rating
Dolly_king_pin_rating	Integer	Dolly Kingpin Rating

Table 4.11: Vehicle Details

Vehicle Configuration

Column	Data type	Description
id	Integer	Vehicle Configuration Identification Number
Unladen_weight_steer	Integer	Unladen Weight for Steer
Unladen_weight_drive	Integer	Unladen Weight for Drive
Unladen_weight_dolly	Integer	Unladen Weight for Dolly
Unladen_weight_trailer	Integer	Unladen Weight for Trailer
Total_unladen_weight	Integer	Total Unladen Weight
Wheels_steer	Variable Character	Wheel-Single, Dual or 4-in-line
Wheels_drive	Variable Character	Wheel-Single, Dual or 4-in-line
Wheels_dolly	Variable Character	Wheel-Single, Dual or 4-in-line

Wheels_trailer	Variable Character	Wheel-Single, Dual or 4-in-line
Tyre_size_type_ply_steer	Variable Character	Tyre Sizes, type and ply rating
Tyre_size_type_ply_drive	Variable Character	Tyre Sizes, type and ply rating
Tyre_size_type_ply_dolly	Variable Character	Tyre Sizes, type and ply rating
Tyre_size_type_ply_trailer	Variable Character	Tyre Sizes, type and ply rating
Tyre_pressure_steer	Integer	Tyre Pressure
Tyre_pressure_drive	Integer	Tyre Pressure
Tyre_pressure_dolly	Integer	Tyre Pressure
Tyre_pressure_trailer	Integer	Tyre Pressure

Table 4.12: Vehicle Configuration

Vehicle Dimensions

Column	Data Type	Description
id	Integer	Vehicle Dimension Identification Number
a	Integer	Vehicle dimension distance in millimeters
b	Integer	Vehicle dimension distance in millimeters
c	Integer	Vehicle dimension distance in millimeters
d	Integer	Vehicle dimension distance in millimeters
e	Integer	Vehicle dimension distance in millimeters
f	Integer	Vehicle dimension distance in millimeters
g	Integer	Vehicle dimension distance in millimeters
h	Integer	Vehicle dimension distance in millimeters
i	Integer	Vehicle dimension distance in millimeters
j	Integer	Vehicle dimension distance in millimeters
k	Integer	Vehicle dimension distance in millimeters
l	Integer	Vehicle dimension distance in millimeters
m	Integer	Vehicle dimension distance in millimeters
n	Integer	Vehicle dimension distance in millimeters
o	Integer	Vehicle dimension distance in millimeters
p	Integer	Vehicle dimension distance in millimeters
q	Integer	Vehicle dimension distance in millimeters
r	Integer	Vehicle dimension distance in millimeters
s	Integer	Vehicle dimension distance in millimeters
Comb_id	Integer	Vehicle Combination ID

Table 4.13: Vehicle Dimensions

Vehicle Combination

Column	Data type	Description
id	Integer	Combination Identification Number
dolly	Boolean	Dolly status
trailer	Boolean	Trailer status
Image_url	Variable Character	Image of Vehicle Combination

Table 4.13: Vehicle Combination

Route Distance Table

Column	Data Type	Description
id	Integer	Route Identification Number
Source	Variable Character	Route Source
Destination	Variable Character	Route Destination
via	Variable Character	Route Marker
Distance	Integer	Distance in Kilometres

Table 4.14: Route Distance Table

Abnormal Load Fee Schedule for Loads

Column	Data Type	Description
id	Integer	Fee Identification Number
Start_eswm	Integer	Start of ESWM Range
End_eswm	Integer	End of ESWM Range
Vehicle_reg_type	Integer	Vehicle Registration Place
Cost_per_km	Integer	Cost per Kilometre

Table 4.15: Abnormal Load Fee Schedule for Loads

Abnormal Load Required Fee Schedule

Column	Data type	Description
Id	Integer	Fee Identification Number
Vehicle_reg_type	Boolean	Vehicle Registration Place (Local or Foreign)
Ab_reg_fee	Decimal(10,2)	Abnormal load registration fee
Minimum_fee	Decimal(10,2)	Minimum fee
With_escort	Decimal(10,2)	Abnormal Size Vehicle load fee with escort
Without_escort	Decimal(10,2)	Abnormal Size Vehicle load fee without escort

Table 4.16: Abnormal Load Required Fee Schedule

Permit Periods

Column	Data type	Description
id	Integer	Permit Period Identification Number
period	Integer	Permit Validity period from date of issue
Vehicle_reg_type	Boolean	Vehicle Registration Place (Local or Foreign)
amount	Decimal(10,2)	Permit price

Table 4.17: Permit Periods

Maximum mass loads limits

Column	Data Type	Description
id	Integer	Axle group Mass Loads Identification Number
Legal_load_steer	Integer	Maximum legal load for steer
Legal_load_drive	Integer	Maximum legal load for drive
Legal_load_dolly	Integer	Maximum legal load for dolly
Legal_load_trailer	Integer	Maximum legal load for trailer
Legal_load_gcm	Integer	Maximum legal load Gross Combination Mass
load_at_eswm3750_steer	Integer	Load at ESWM 3750(kg) for steer

load_at_eswm3750_drive	Integer	Load at ESWM 3750(kg) for drive
load_at_eswm3750_dolly	Integer	Load at ESWM 3750(kg) for dolly
load_at_eswm3750_trailer	Integer	Load at ESWM 3750(kg) for trailer
load_at_eswm3750_gcm	Integer	Load at ESWM 3750(kg) Gross Combination Mass
Max_perm_load_steer	Integer	Maximum permitted load Steer
Max_perm_load_drive	Integer	Maximum permitted load Drive
Max_perm_load_dolly	Integer	Maximum permitted load Dolly
Max_perm_load_trailer	Integer	Maximum permitted load Trailer
Max_perm_load_gcm	Integer	Maximum permitted load Gross Combination Mass
Eswm_at_max_perm_load_steer	Integer	ESWM (kg) at Maximum permitted load steer
Eswm_at_max_perm_load_drive	Integer	ESWM (kg) at Maximum permitted load drive
Eswm_at_max_perm_load_dolly	Integer	ESWM (kg) at Maximum permitted load dolly
Eswm_at_max_perm_load_trailer	Integer	ESWM (kg) at Maximum permitted load trailer
Tyre_pressure_steer	Integer	Tyre Pressure Steer
Tyre_pressure_drive	Integer	Tyre Pressure Drive
Tyre_pressure_dolly	Integer	Tyre Pressure Dolly
Tyre_pressure_trailer	Integer	Tyre Pressure Trailer
Sum_of_steer_and_drive	Integer	Sum of Steer and Drive massloads
Gcm	Integer	Gross Combination Mass
Max_payload	Integer	Maximum payload
Advice_id	Integer	Advice for Certification ID (FOREIGN KEY)

Table 4.18: Maximum mass loads limits

Axle Group Mass Loads and Speeds

Column	Data Type	Description
id	Integer	Axle group mass loads and speeds Identification Number
80_km_hr_steer	Integer	Steer axle mass at 80 km/hr
80_km_hr_drive	Integer	Drive axle mass at 80 km/hr
80_km_hr_dolly	Integer	Dolly axle mass at 80 km/hr
80_km_hr_trailer	Integer	Trailer axle mass at 80 km/hr
50_km_hr_steer	Integer	Steer axle mass at 80 km/hr
50_km_hr_drive	Integer	Drive axle mass at 80 km/hr
50_km_hr_dolly	Integer	Dolly axle mass at 80 km/hr
50_km_hr_trailer	Integer	Trailer axle mass at 80 km/hr
30_km_hr_steer	Integer	Steer axle mass at 80 km/hr
30_km_hr_drive	Integer	Drive axle mass at 80 km/hr
30_km_hr_dolly	Integer	Dolly axle mass at 80 km/hr
30_km_hr_trailer	Integer	Trailer axle mass at 80 km/hr
Advice_id	Integer	Advice for Certification ID (FOREIGN KEY)

Table 4.19: Axle Group Mass Loads and Speeds

Bridge Limitations

Column	Data Type	Description
id	Integer	Bridge Limitation Identification Number
Route_number	Integer	Route Number
Bridge_name	Integer	Bridge Name
Max_gcm_or_gvm	Integer	Maximum permitted GCM or GVM (kg)

Table 4.20: Bridge Limitations

Advice for Certification Bridge Limitations

Column	Data type	Description
id	Integer	Record Identification Number
advice_id	Integer	Foreign Key (Advice for Certification table)
Bridge_limitation_id	Integer	Foreign Key (Bridge limitation table)

Table 4.21: Advice for Certification Bridge Limitations

Abnormal load permit application

Column	Data Type	Description
id	Integer	Permit Application ID Number
date	Date	Date of application
Avr_no	Integer	Foreign Key (Abnormal Vehicle Registration)
Length_loaded	Integer	Length of Vehicle when loaded
Length_unloaded	Integer	Length of Vehicle when unloaded
Width_loaded	Integer	Width of Vehicle when loaded
Width_unloaded	Integer	Width Vehicle when unloaded
Height_loaded	Integer	Height of Vehicle when loaded
Height_unloaded	Integer	Height of Vehicle when unloaded
Front_projection	Integer	Front projection
Rear_projection	Integer	Rear projection
Each_side_projection	Integer	Each side of projection
Mass_of_load	Integer	Mass of the load
Each_side_height_above_ground	Integer	Each side height above ground
Front_height_above_ground	Integer	Front height above ground
rear_height_above_ground	Integer	Rear height above ground
Steer_max_mass_load	Integer	Steer maximum mass load
drive_max_mass_load	Integer	Drive maximum mass load
dolly_max_mass_load	Integer	Dolly maximum mass load
trailer_max_mass_load	Integer	Trailer maximum mass load
total_max_mass_load	Integer	Total maximum mass load
Route_no	Integer	Foreign key (Routes Table)
Date_of_movement_from	Date	Date of movement start date
Date_of_movement_to	Date	Date of movement end date

Table 4.22: Advice for Certification Bridge Limitations

Abnormal size vehicle permit application

Column	Data type	Description
id	Integer	Application ID Number
date	Date	Date of application
Vehicle_length	Integer	Length of vehicle
Vehicle_width	Integer	Width of vehicle
Vehicle_height	Integer	Height of vehicle
Dolly_length	Integer	Length of dolly
Dolly_width	Integer	Width of dolly
Dolly_height	Integer	Height of dolly
Trailer_length	Integer	Length of Trailer
Trailer_width	Integer	Width of Trailer
Trailer_height	Integer	Height of trailer
Overall_length	Integer	Overall length
Overall_width	Integer	Overall width
Overall_height	Integer	Overall height
Gross_train_mass	Integer	Gross train mass
Reason_for_dim_excess	Variable Character	Reason for dimensional excess
Route_number	Integer	Route Identification Number
Mov_date_from	Date	Date of movement
Mov_date_to	Date	Date of movement

Table 4.23: Abnormal size vehicle permit application**Abnormal Size Vehicle Permit**

Column	Data Type	Description
id	Integer	Permit ID Number
date	Date	Permit Date of Issue
App_id	Integer	Foreign Key (Permit Abnormal Size Application)
Receipt_no	Integer	Receipt Number
Max_speed	Integer	Maximum permitted speed
Escort_req	Variable Character	Escort Requirements
Valid_until	Date	Permit Expiration
Permit_type	Variable Character	Type of permit

Table 4.24: Abnormal Size Vehicle Permit**Tredco_dual_wheeled**

Column	Data type	Description
id	Integer	Record Identification Number
Tyre_size	Integer	Tyre Size
Wheel_spacing	Integer	Wheel spacing in millimetres
Eswm3750_load	Integer	Maximum permitted load at ESWM 3750 (kg)
Eswm5000_load	Integer	Maximum permitted load at ESWM 5000 (kg)
ctip	Integer	Cold tyre inflation pressure

Table 4.25: Tredco_dual_wheeled

4.7 Program Design

Program design is a method of documenting methods and procedures of a software (McConnell, 1999). It is written in plain English language without any suggestion to a particular programming language as is the case with pseudo-code. However, program design is closely related to pseudo-code except for the difference noted earlier on that it does not suggest of any particular language (McConnell, 1999). Program design also include the use of sequence diagrams and package diagrams to illustrate the interaction of program modules and the users respectively.

4.7.1 Package Diagram

This is a brief expression of how the software components of the proposed system interacts that is the grouping of classes into packages (Lambrou *et al*, 2002). A package is defined as collection of logically related elements which is difficult to describe without using diagrams. So UML package diagrams are employed to reduce the complexity of illustrating logically related elements (Schmidt, 2003).

Package Diagram for Abnormal Load Advisory System

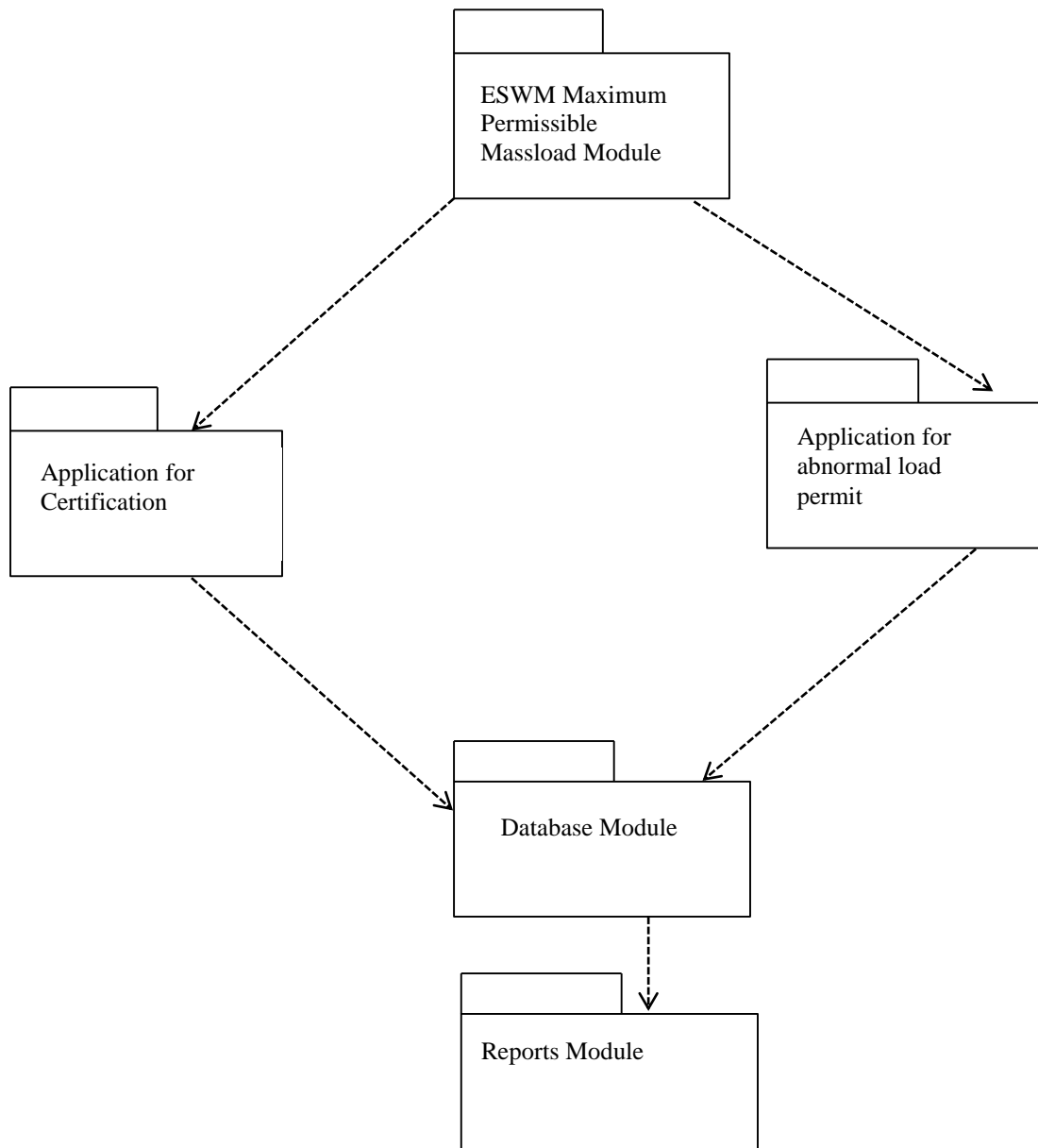


Figure 4.8: Package diagram for Abnormal Load Advisory System

Key

	Module
	Dependencies
	Data flow

Table 4.26: Package Diagram Key

4.7.2 Class Diagram

Class diagram is grouping diagrammatic representation that depicts grouping of objects sharing the same set of methods and attributes (Date, 2005). It is these methods and attributes which when combined define a class. Also included on class diagrams is the representation of how these classes interact (Everest, 2001). Class diagrams are static in nature as they display what interacts between classes and interfaces but not what happens when interaction takes place (Sommerville, 2001). The connections are reflected through associations. It should be noteworthy that generalizations and aggregations are important in reflecting inheritance and composition; features of classes that are prevalent in class diagrams. **Fig 4.9: Class Diagram of Abnormal Load Advisory System** show the main classes of ALAS.

4.7.2.1 Class Diagram for Abnormal Load Advisory System

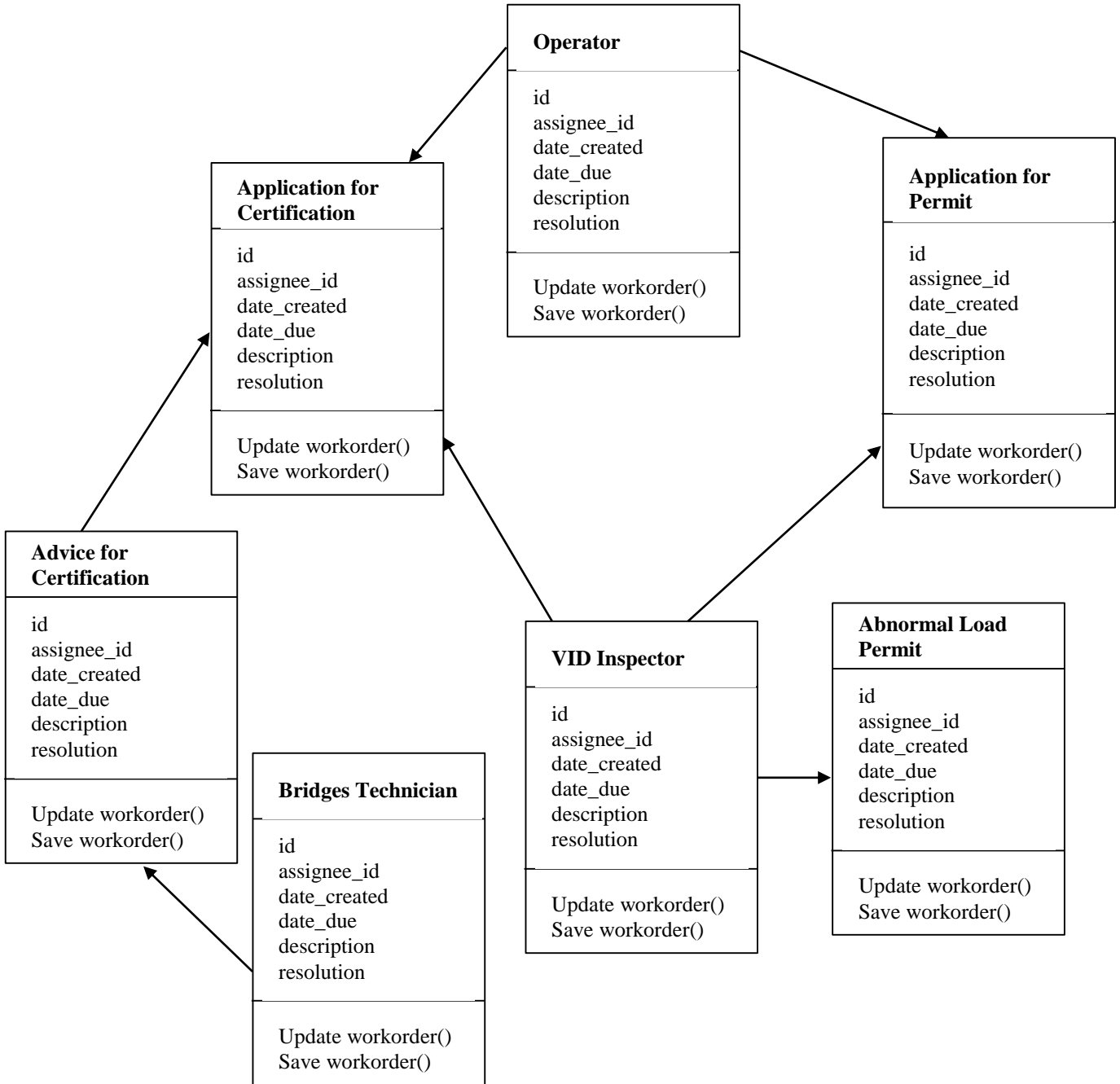


Figure 4.9: Class Diagram for Abnormal Load Advisory System

4.7.3 Sequence Diagram

Sequence diagram is a graphical representation of object interactions arranged in time sequence (Merzirow, 2008:116). It shows objects and classes in a scenario and the sequence of message exchange between the involved objects to fulfil functionality of the scenario (Kilgannon, 1984). It is useful in system logic validation and system documenting as it models system flow. The diagram is read from left to right going downwards as is shown in **Fig 4.10: Application for Abnormal Load Certification Registration**. For clarity sake, the sequence diagrams are divided into three main processes making up the system that is Application for Abnormal Load Certification Registration (Registration) and Application for Abnormal Load Permit (Permit Processing) as has been done with DFDs in Chapter 3 Analysis Phase.

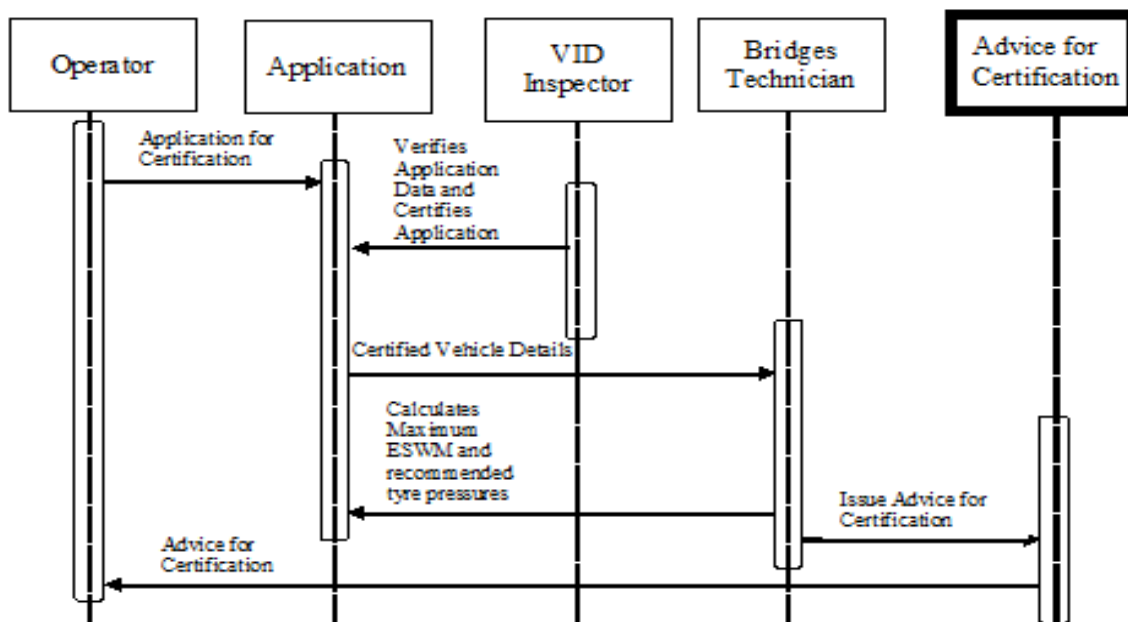





Figure 4.10: Application for Abnormal Load Certification Registration

Symbol	Description
	Class
	Focus
	Message

	Lifeline
--	----------

Table 4.27: Key for sequence diagrams

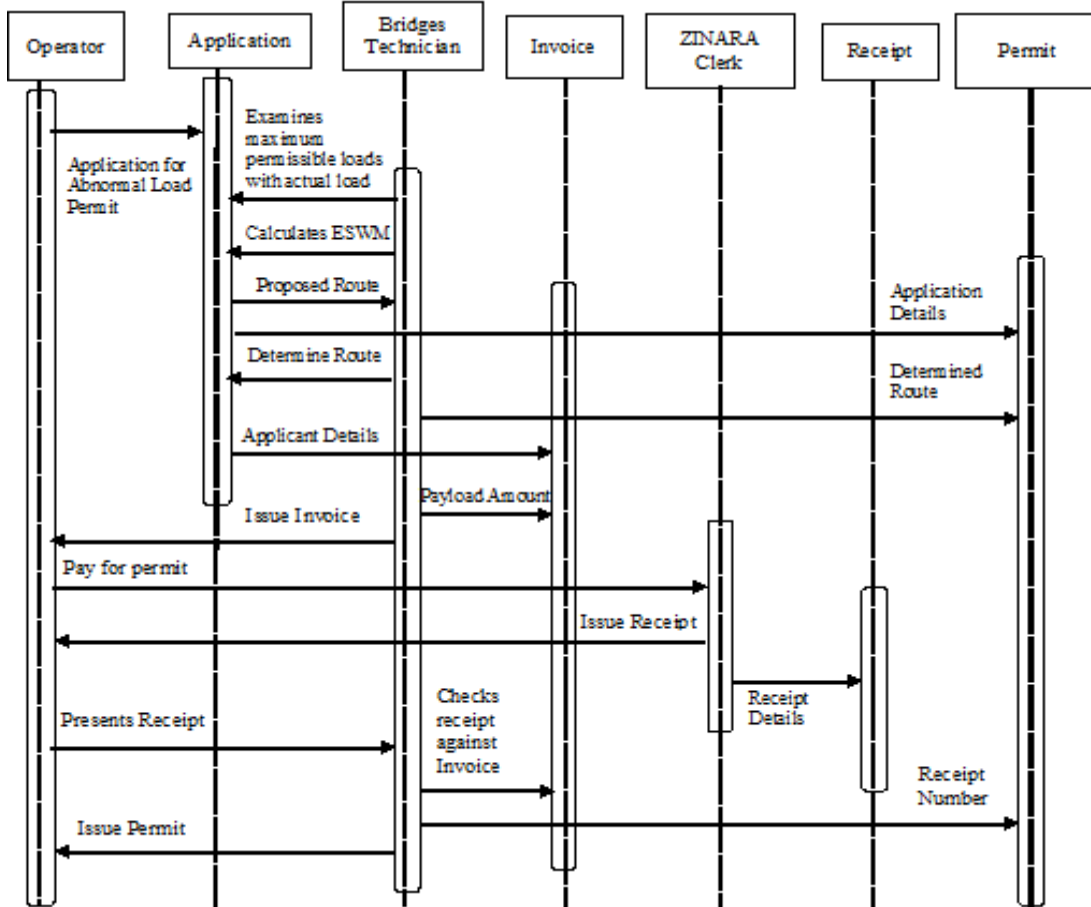


Figure 4.11: Application for Abnormal Load Permit

Symbol	Description
□	Class
	Focus
→	Message
	Lifeline

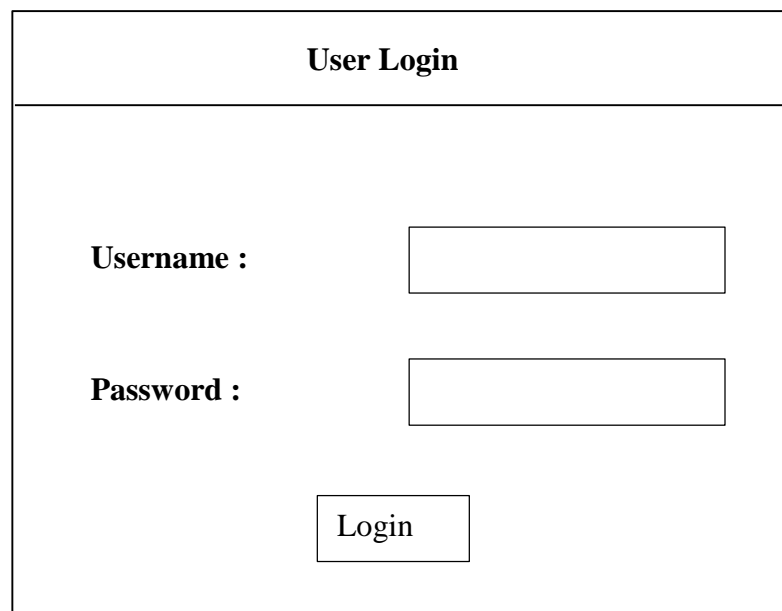
Table 4.28: Key for sequence diagrams

4.8 Interface Design

Interface design is the process of developing a method for two or more modules in a system to communicate (Sanders and McCormick, 1997). User interface has a great impact on the quality of a system as it provides for the communication between user and the system. So it is important to design a user interface that makes users navigate through the system without any difficulties. Interface design is composed of input and output design.

4.8.1 Input Design

Input design involves the design of the new system's input forms through which users input all the necessary data into the system for example application for advice for certification of abnormal load (Registration) and application for abnormal load permit details.



The diagram shows a rectangular box representing a user login screen. At the top, the text "User Login" is centered. Below this, there are two rows of input fields. The first row is labeled "Username :" followed by a rectangular input box. The second row is labeled "Password :" followed by another rectangular input box. Below these two rows, centered, is a rectangular button labeled "Login".

Figure 4.12: User login screen

New User

New User	
Name:	<input type="text"/>
Surname:	<input type="text"/>
Username:	<input type="text"/>
Password:	<input type="text"/>
Email:	<input type="text"/>
Phone Number:	<input type="text"/>
Role:	<input type="text" value="Select Role"/> ▼
<input type="button" value="Save"/>	<input type="button" value="Cancel"/>

Figure 4.13: New user input form

4.8.2 Menu Design

Management Main Menu

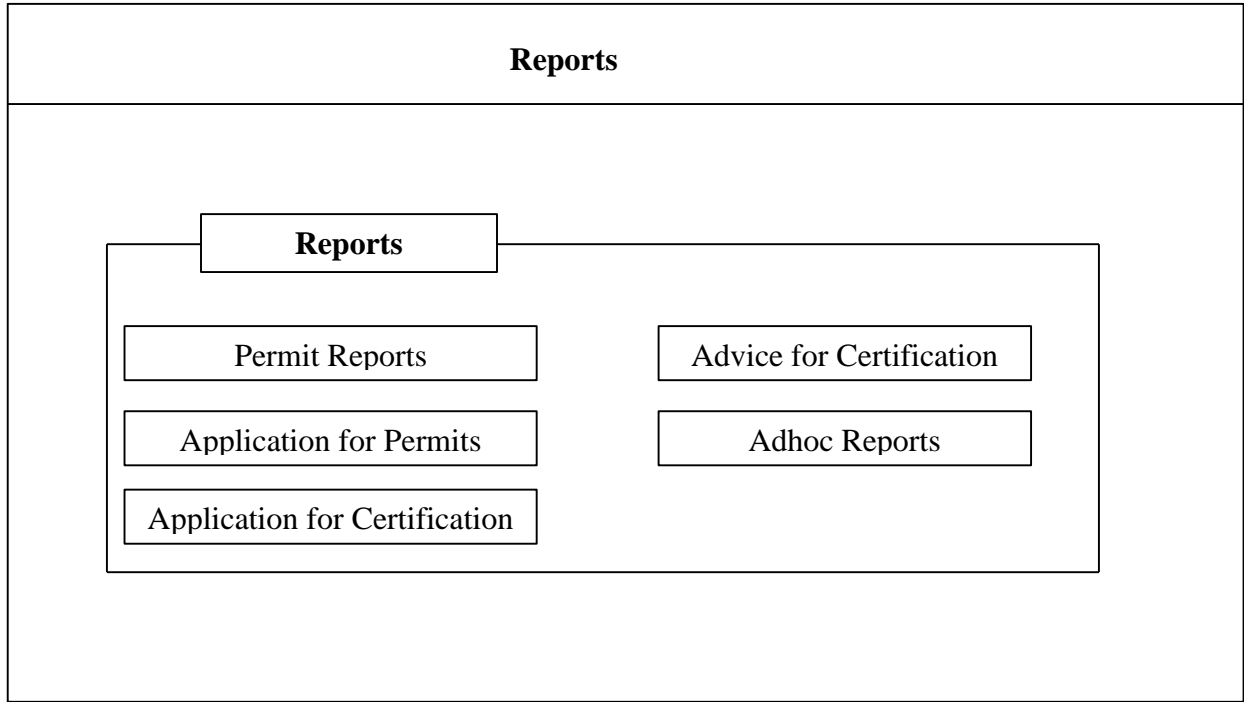


Figure 4.14: Management main menu

Applications	Permits	Advice for Certification	Invoices

Figure 4.15: Clerk main menu

4.8.3 Output Design

Output design is the way by which data processed by the system into information is delivered to the users. Output is mostly composed of information that users require in accomplishing their day to day tasks. It from the output that the system's effectiveness is measured (Perry, 1998).

Application for Certification of Abnormal Vehicle Combination			
Application ID	Applicant	Date of Application	Inspected By

Figure 4.16: Application for Abnormal Vehicle Load Combination

Advice for Certification of Abnormal Vehicle Combination				
Advice for Certification List				
AVR No	Vehicle Reg	Certification Date	Expiry Date	View
	no			

Figure 4.34: Advice for Certification of Abnormal Vehicle Combination

Abnormal Load Permit:				
Abnormal Load Permits				
Permit Id	AVR No	Issue Date	Expiry Date	Permit Type

Figure 4.35: Abnormal Load Permit

4.9 Conclusion

This chapter dwelt more on proposed system design issues expressing on how the system will be working. There is an old common saying which says a picture describes more and explicit than words can do. So most of the description on how the proposed system would work was illustrated using UML diagrams which provided for a visual explanation of the system components that is inputs, processes and outputs. Also shown by the diagrams is how the components interact to make up the system. Having the system design in place, the next step is the implementation phase which constitutes Chapter 5. Implementation phase involves transformation of the design into a working model that meets the user requirements thus construction of the software system.

CHAPTER 5: IMPLEMENTATION PHASE

5.1 Introduction

Implementation phase is concerned with converting the system design defined in the design phase into actual software system (Spool and Hoekman, 2006). Implementation phase's thrust is on checking the new system against the objectives formulated in Chapter 1: Introduction. Key activities of the phase are installing and releasing the new system in its target environment and the supporting activities are training of end users (Sumner, 2003). It also explores the coding strategy, testing and functionality. To ensure conformity of the system to the user's requirements, the system has to pass rigorous testing before it is delivered to the users. Also, of importance is user training on the system that has to be conducted in order to facilitate smooth flow of operations when the new system is adopted. Furthermore, system conversion is explored, and system conversion refers to changeover method to be employed from the current system to the new system (Hughes and Cotterrell, 2006).

5.2 Coding of the System

System coding is all about turning program logic to specific instructions that are to be executed by the computer (Sommerville, 2001). Dreamweaver development environment embedded on PHP and Java Script running on Wamp server, interacting with MySQL database was used to develop the web pages. First to be constructed was the system database using MySQL database management system (MySQL DBMS). The application on which MySQL DBMS runs on is phpMyAdmin.

5.2.1 Pseudo code of the system

Pseudo code are plain English statement showing the overview of how the system works without suggesting any particular language (French, 1998). The following is part of system's pseudo code:

Log In Pseudo Code

Start

Select username and password

Do

If (username and password) valid Then
Log in
Else
Wrong (username or password) Try again.
End if
While trials is less than 4 times
Close connection
If (username == admin) AND (password == admin) Then
Enable Administrator Main Menu
Executive main menu = disable
Else
Administrator of Main Menu = disable
Executive of main menu = enable
End If
show Menu Form
End

Pseudo Code for Application for Advice Certification Abnormal Load (Registration)

Input
VID Depot
Operator Name
Company name
Date of application
Contact number
Vehicle registration number
Number of axles

Validate user input
If input is valid then

Connect to database
Select appropriate Table

Check if record exists
If record exists then
Notify user
Abandon procedure
Else
Add record
Notify user of transaction
End If

Pseudo code for Application for Abnormal Load Permit (AALP)

Input
AVR number
If AVR_number exist
Enter load mass
If load mass is less or equal to advice maximum limit Then
Enter proposed route
Else reject application
Else refer to application for advice for certification of abnormal load
End

5.3 Testing

This refers to complete, integrated system evaluation of the system's compliance with the specific user requirements (Black, 2002). Testing is carried out in order to deliver a system that meets the user's requirements. The system is measured by comparing output against the established objectives. It includes the following attributes:

- Security constraints check
- Minimised unauthorized data usage
- Check if the system is navigable and is allowing authorized users to add, delete and edit records.

Testing is actually a process that goes through five basic stages which include unit, module, sub module, system and acceptance testing (Sommerville, 2001). This is illustrated in **Figure 5.1:**

Testing Phases.

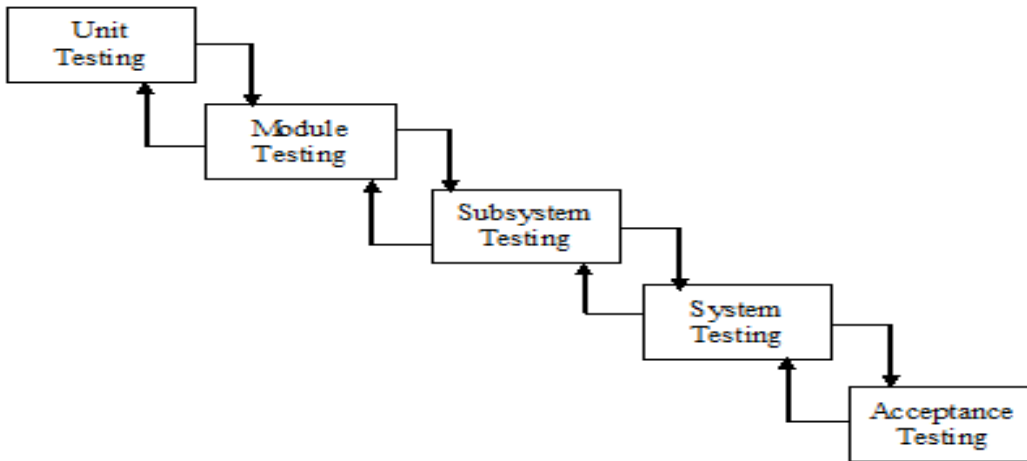


Figure 5.1: Testing Phases

Source: (Sommerville, 2001)

5.3.1 Unit Testing

Unit testing is a technique for testing a unit of program that is a function or module. This implies testing of system components independent of other components that they interact with to make up the system (Kolawa and Huizinga, 2007: 146). There are two techniques employed in unit testing and that is black box and white box testing.

5.3.1.1 Black Box Testing



Figure 5.2: Black Box

Source: (Kaner, 1999)

Black box testing involves testing the unit with the only known elements being inputs and outputs without any knowledge of the internal operations of the unit (Sommerville, 2001). It involves checking the outputs such as reports to see if they are coming out as per user requirements. All

that goes in are the inputs which are known. The processing of the inputs is not known to the world but outputs are realized which are different from the inputs implying that there is some processing that would have taken place inside the unit hence that name black box. A black box literally blinds the world from its contents but what goes in a black box can be seen as well as what comes out of the box.

5.3.1.2 White Box Testing

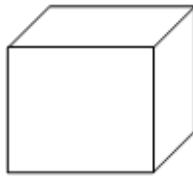


Figure 5.3: White Box

Source: (Kaner, 1999)

White box testing focuses on the internal working detail of the unit being tested (Black, 2002). Errors not shown on black box testing are revealed by the white box testing. A unit may produce the required output but the program might be having bugs that are never revealed by the black box.

5.3.2 Module Testing

Module testing involves the testing of complete code objects as produced by compiler code when built from source (Turner and White, 2012). Different units within a module are combined to test on functionality of the module as a whole. The purpose of module testing is to access to see if a group of units that are supposed to work together to make up a module are doing so without errors (Kolawa and Huizinga, 2007). Module testing is a build up to unit testing.

5.3.3 Subsystem Testing

This involves testing of a collection of modules that have been integrated to make up a subsystem. This ensures detection of interface mismatch and thorough testing of interfaces between programs (Zaitsev and Tkachenko, 2012). ALAS Modules linked together such as AALAC and AALP were tested to see if they were coordinating to make up a subsystem and it was a success.

5.3.4 System Testing

This is a build-up on module testing as all the programs of the whole system are tested in a holistic approach thereby ensuring a measure of the whole system efficiency and effectiveness (Black, 2002). System functionality is measured against the stated objectives thus evaluation of the system as a whole. Essential functions such as security and output generation will be taken into account as users go through the system. Other issues taken into consideration include hardware and software compatibility and how the system will adapt to environment (Sommerville, 2001). The environment include factors such as viruses.

5.3.5 Acceptance Testing

Acceptance testing completes the testing process as it is the last stage of the testing process. It is performed by the users to certify conformity of the system with the user requirements with attention being paid on the stated objectives (McFarlin, 2012). The system is tested with data supplied by the user and not simulated data. This is a continuous exercise until the users are satisfied with system such that they accept that the system is surely working accordingly. The main purpose of acceptance testing is to access for user acceptance of the system as a whole (aiu.inc, 2012). Acceptance comprises of alpha testing and beta testing

5.3.5.1 Alpha Testing

Alpha testing is first test carried out on a newly developed system I the laboratory using simulated data input and environment before it is taken to the actual users (Kaner, Falk and Nguyen, 1999). These are set of activities that ensure that implementation of particular function by software packages are correctly done so (Kaner, 2006). The primary function of alpha testing is to look for omissions and errors with regards to design specifications that were not fulfilled during construction but were specified at the design phase. Actual system is compared against requirements specifications to prove that the system actually solves the identified problems or better still covers more than required. Once this test has passed it can be concluded that the system is perfect for MOTID.

5.3.5.2 Beta Testing

Beta testing is testing of the system done after alpha testing and just before system launch done in the real environment using real data and users with feedback covering every element of the product (Binder, 1999). This testing aims at testing validity of data being entered into the system that is data validation. It is usually characterized by a fewer bugs compared to alpha testing and most of the feedback collected is considered for implementation in future versions of the system (Boris, 1990). This provides for system delivers readiness.

5.3.6 Test Strategies

This is an outline description of the testing approach employed in testing the system highlighting key issues of the process such as the objectives of testing, methods for testing functions, sum of resources and time required for the whole project and the testing the environment (Amman and Offutt, 2008).

a.) Validation

This is an evaluation to check if the system has been built right through measuring to see if the system is correct, complete, being implemented as intended and delivering the intended outcome (Boris, 1990). Different objectives of the system were assessed to see if they were achieved for example entering text character in a field requiring integers, an error message pops up as is shown on **Figure 5.1**. This process was done in order to deliver an error free system

Operator	<input type="text"/>	✖ Operator is required
Truck Registration Number	<input type="text"/>	✖ Please enter the truck registration number
Truck Make	22	✖ Please enter only alphabetic letters
Truck Model	Nissan	✔
Truck Net Mass	28000	✔
Maximum Gross Combination Mass	dshjskj	✖ Please enter a valid mgcm
Maximum Gross Vehicle Mass	/:ii	✖ Please enter a valid mgvm
Front Axle Rating	15000	✔
Rear Axle Rating	sdsd	✖ Please enter a valid number.
Engine Make	<input type="text"/>	✖ Please enter engine make
Engine Model	<input type="text"/>	✖ Please enter engine model
Power at Clutch	<input type="text"/>	✖ Please enter user phone
<input type="button" value="Submit"/>		

Figure 5.4: Input Validation

5.3.7 Objectives Versus System Solution

1. To make it possible to register units of a truck as independent units that is horse, trailer and dolly and then maintain a repository of the e units such that a combination of different registered units can be made without making new registration of the whole combination

Horse Details

Operator	<input type="text"/>
Truck Registration Number	<input type="text"/>
Truck Make	<input type="text"/>
Truck Model	<input type="text"/>
Truck Net Mass	<input type="text"/>
Maximum Gross Combination Mass	<input type="text"/>
Maximum Gross Vehicle Mass	<input type="text"/>
Front Axle Rating	<input type="text"/>
Rear Axle Rating	<input type="text"/>
Engine Make	<input type="text"/>
Engine Model	<input type="text"/>
Power at Clutch	<input type="text"/>

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Figure 5.5: Horse Registration

ABNORMAL

LOAD ADVISORY

SYSTEM

[Home](#)
[Application For Certification](#)
[Edit Vehicle Combination](#)
[Application For Abnormal Load Permit](#)
[Account](#)

Trailer Details

Operator	<input type="text"/>
Registration Number	<input type="text"/>
Make	<input type="text"/>
MGVM	<input type="text"/>
Net Mass	<input type="text"/>
Axle Rating	<input type="text"/>
Kingpin Rating	<input type="text"/>

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Figure 5.6: Trailer Registration

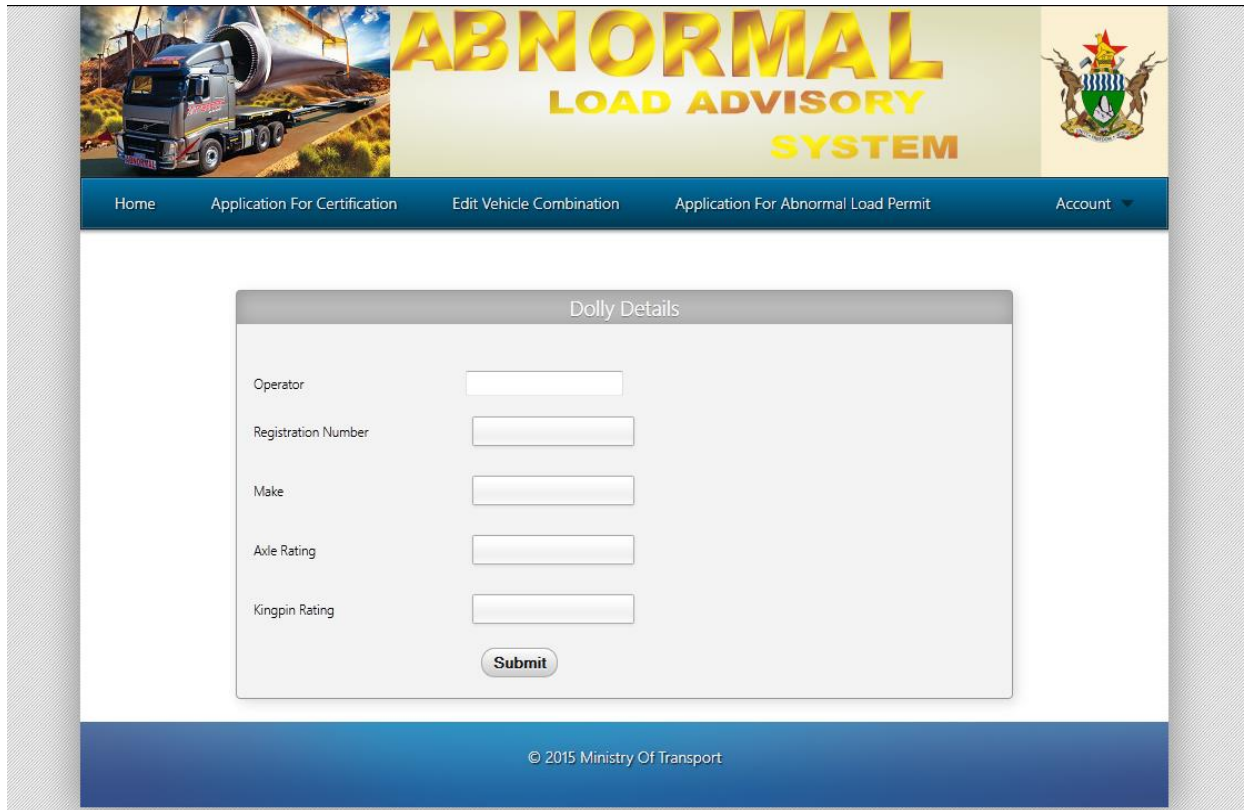


Figure 5.7: Dolly Registration

Application For Certification Of Abnormal Load Combination

Operator:

COMBINATION UNITS

Horse Registration Number:

Dolly Registration Number:

Trailer Registration Number:

Vehicle Image: No file selected.

VEHICLE DIMENSIONS

A:

B:

C:

D:

Figure 5.8: Registration of Different Units

2. To provide for one stop service in abnormal load regularization modalities by making abnormal load permit application, registration, load payment be done in one office so as to save time and improve on efficiency of the system.

Application For Certification Of Abnormal Load Combination

Operator:

COMBINATION UNITS

Horse Registration Number:

Dolly Registration Number:

Trailer Registration Number:

Vehicle Image: No file selected.

VEHICLE DIMENSIONS

A:

B:

Figure 5.9: Application For Certification Of Abnormal Load Combination

ABNORMAL LOAD ADVISORY SYSTEM

Home Application For Certification Edit Vehicle Combination Application For Abnormal Load Permit Account

Applicant And Vehicle Details

Owner's Name	Norman Chinembiri
Address	10 St Andrews Rd Hatfield Harare
Truck Registration Number	ABC8970
Dolly Registration Number	AGM5389
Trailer Registration Number	AFG1029
Vehicle Registration	Please Select

VEHICLE DIMENSIONS AND LOAD

Length when Loaded

Length when Unloaded

Width when Loaded

Width when Unloaded

Height when Loaded

Figure 5.10: Abnormal Load Permit Application

ABNORMAL LOAD ADVISORY SYSTEM

Home Issue Invoice Issue Permit View Permits Account

Please Enter Invoice Number:

Invoice List

Date	Invoice Number	Applicant Name	Amount (\$)	Receipt
2015-05-18	2	Norman Chinembiri	234.90	Receipt

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Figure 5.11: Invoice

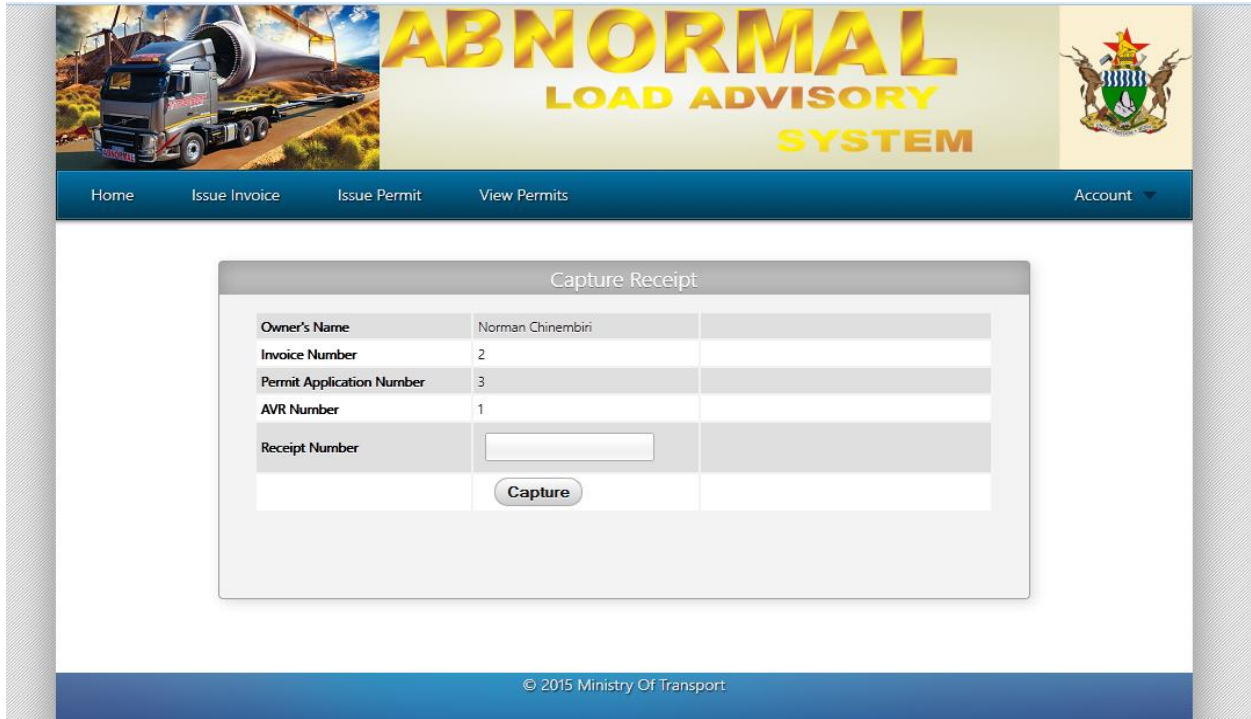


Figure 5.12: Receipting

3. To determine a suitable route for particular abnormal load as some roads have different widths and designs including bridges on the route that have different load capacity they can accommodate in terms of weight and size.

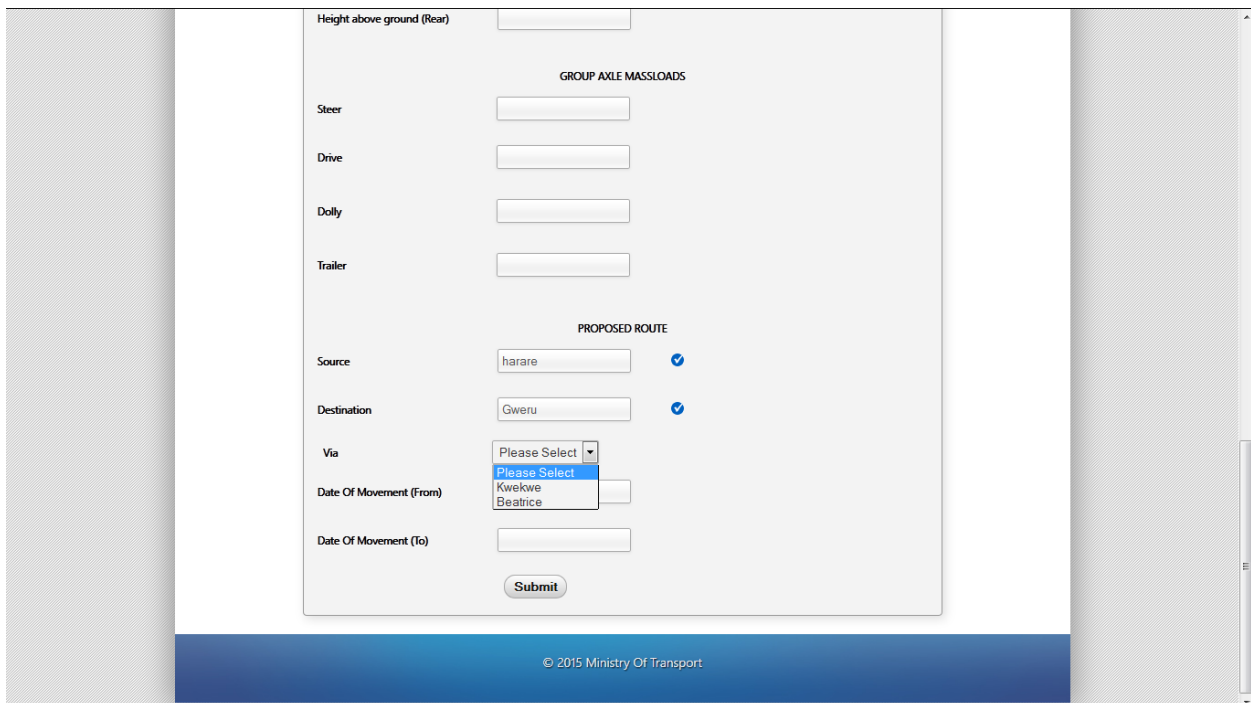



Figure 5.13 Route Determination

4. To issue abnormal load permits automatically generated by the system so as to reduce human errors in calculation of load per kilometer cost and axle loading of the vehicle.



GOVERNMENT OF ZIMBABWE

ABNORMAL LOAD PERMIT

The minister of Transport hereby grants exemption from the provisions of section 4 of the Road Traffic (Axle Loading) Regulations, 1977, and from the provisions of sections 4, 5 and 6 of the Roads and Road Traffic (Construction, equipment and use) Regulations, 1972, for the movement of the vehicle and load described on the application form, over the route specified during the period requested, subject to the following conditions.

Date: 2015-05-21	Owner's Name: Norman Chinembiri	AVR No: 1
Truck Reg No: ABC8970	Dolly Reg No: AGM5389	
Trailer Reg No: AFG1029		
Source: Harare	Destination: Bulawayo	Via: Gweru
Date of Movement: 2015-05-20 to 2015-05-22		

A. The gross axle massloads shown in the application shall not be exceeded

Steer: 7500	Drive: 21000	Dolly: 28000	Trailer: 30000
-------------	--------------	--------------	----------------

B. Cold inflation tyre pressures must not exceed (kPa):-

Steer: 425	Drive: 436	Dolly: 436	Trailer: 520
------------	------------	------------	--------------

C. The following speeds must not be exceeded -

Urban:	Rural:	Over Bridges:
--------	--------	---------------

D. Standard permit conditions: 1-11 Inclusive applied

E. The Gross massload on the drive axle group must not be less than 20 per cent of the gross combination mass for an articulated trailer or 15 percent for an independent trailer.

F. Escort Requirements:

G. Warning Sign Requirements -

- (i) Bright and red flags at least 600 mm x 600 mm attached to vertical poles mounted on the extremities of the vehicle
- (ii) Warning boards at least 2 000mm wide 300mm high and bearing the word "ABNORMAL" in red letters 200mm high on a white background to be mounted front and rear
- (iii) A flashing amber beacon light to be fitted to the vehicle and illuminated whenever the vehicle is on the road.

Figure 5.14: Abnormal Load Permit

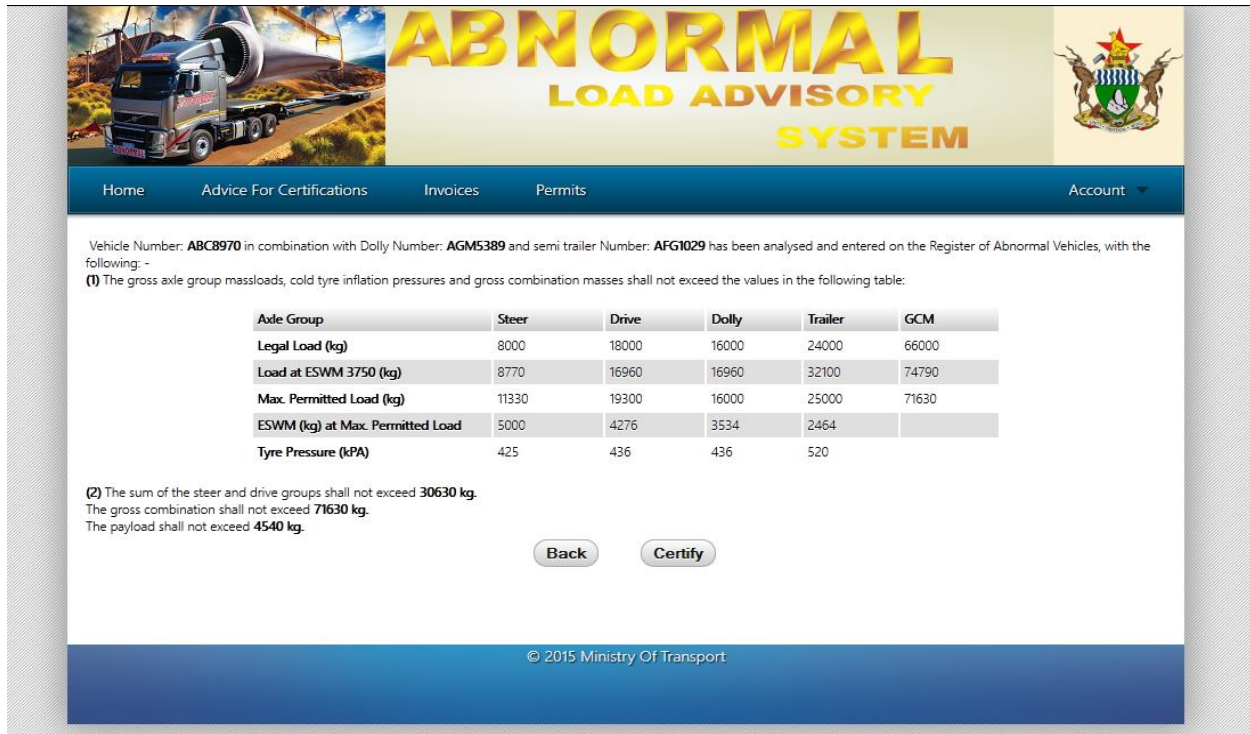


Figure 5.15: System Computations

5. To provide for a safe movement of abnormal load vehicles in Zimbabwe through provision of abnormal load spot checks for compliance at any point. Operators sometimes load the vehicle beyond the permit limit especially when there is no vid weigh bridge from source to destination of operator. So they evade paying for the abnormal load

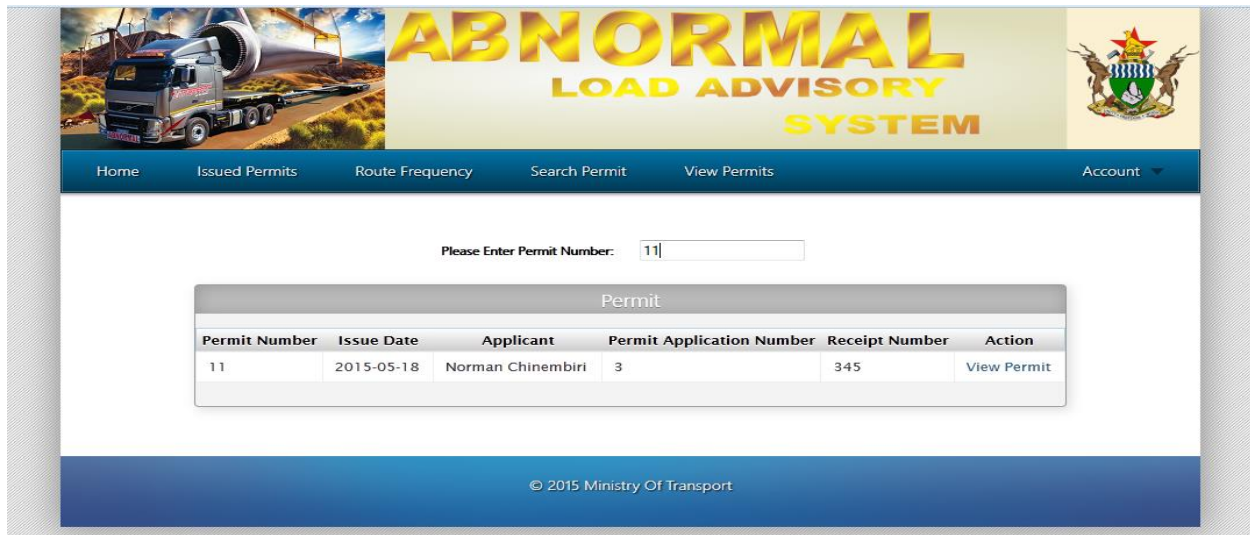


Figure 5.16: Permit Search Form



Figure 5.17: Abnormal Load Permit

b.) Verification

Verification is the process of proving correctness, accuracy and rightfulness of the system that is to find out if the system is right (Whitten *et al*, 1996). The ALAS was tested to see if it was meeting the specific user requirements. It is possible that a system might be having all its functions coordinating and working well but not meeting the specified user requirements. It is through verification when a system is said to be right or wrong. So ALAS was tested to see if for example it could register units of an abnormal load combination as single units to facilitate changing of units of an abnormal vehicle combination when a unit breaks down without going through the process of registration again. White box testing was employed to ensure that all the internal operations of the system were working as per user requirements.

c.) Security Testing

Security testing is a process of showing out flaws in the system's security mechanisms which maintain and protect data as intended (Binder, 1991). Security requirements include confidentiality, integrity, authentication, authorization, availability and non-repudiation. Security is implemented through physical and software measures. Physical security involve

the use of physical barriers to accessing the system such as keeping the system hardware under lock and key (French, 1998). Software security involves mechanisms that make use of software in restricting access to system data and information. This can be achieved by the use of password and access levels. Different users have different access levels in the ALAS.

5.4 Installation

Installation sometimes referred to as setup refers to the activities involved in making program ready for execution (Perry, 1998). It involves the setup of software programs necessary for the system to operate.

5.4.1 Steps for Software Installation

- First install Wamp server software
- Install the system on folder Wamp on C drive that is C:\Wamp\www.
- Connect data source to the database on the main server housing the database

5.4.2 Method of Conversion

Method of conversion refers the transitional process of changing from the old system to the newly developed system as the old system is retired (Eason, 1988). There are four basic methods of conversion from the old system to the new system (Stair & Reynolds 2008). The four system change over approaches are as follows:

- Direct Changeover
- Parallel Conversion
- Phased Conversion
- Pilot Conversion

5.4.2.1 Direct Changeover

The other name for direct changeover is direct cut off or 'Big Bang'. It causes direct change over to the new system immediately when the new system is online (Eason, 1988). It is referred to as the big bang because it relates to the cosmological theory 'Big Bang' where start of the cosmos began at one moment in time (Koop, Roomans and de Theye, 2003). The old system is stopped

immediately when the new system is installed. The biggest advantage with this approach is that it relatively involve lower implementation costs. However, high risk is imminent if the new system fails (Koop, Rooimans and de Theye, 2003).

5.4.2.1.1 Advantages

- Relatively lower costs incurred because one system is running at any given time
- Training is only for the new system and not for the changeover transition period.
- Changeover date is definite and is known by every stakeholder in advance.
- Implementation period is very short such that there is no involvement of updating user documentation.
- The new system is all there is making it unnecessary to design special interfaces used only for the purposes of changeover from the old system to the new one

5.4.2.1.2 Disadvantages

- Fall back plans are difficult to come up with and it becomes more complicated when big bang has already taken place
- Operating the system is impossible when errors are discovered after changeover especially where corrections are needed immediately. Completeness and validity of the converted data can only be proved during the pre-phases but not in a complete system situation.
- A lot of pressure is involved as there is a definite changeover date dead line that has to be met. This leaves the system vulnerable to being delivered pre-mutually resulting in errors during operation.

5.4.2.2 Parallel Conversion

Parallel conversion involves running both the old and new system concurrently for a given time as the two systems are being compared so as to make trade-offs between cost and risk (Neeman and Sarlin, 2007:60). However, parallel conversion is regarded as the most expensive changeover approach since it involves running of two different systems at the same time to achieve similar goals (Mallach, 2009:5). Both systems operate all activities and the results are compared. Once there is confidence with the new system then the old one is shut down. Running two systems at the same time entails an extra investment in terms of human resources that has to go through a

stressful exercise of parallel running where there are chances of procedures crossing each other (Eason, 2003). It is best suited when the likelihood of failure of the new system is high and continuance of the system is critical (Miller and Brabston, 2005).

5.4.2.2.1 Advantages

- Risk is minimized on major flaws in the system as there is always another alternative which is the old system which cushions the fall if the new system fails.
- Quality of the new system is highly likely to be far better than old system as there is always being immediate comparison to the old system

5.4.2.2.2 Disadvantages

- Involves relatively high costs as there are two systems running concurrently but trying to achieve the same goal.
- More work is involved as it involves duplication of the same data input in the two system

5.4.2.3 Phased Conversion

Also referred to as modular conversion which involves changing part of the system whilst the rest of the system remains unchanged (Mallach, 2009). Problems are localized to the new module so that resources are concentrated to the module. This however has a challenge when it comes to interfaces where modules share data (Miller and Brabstone, 2005). The challenges are posed by interface compatibility problems. Several instances of installation of modules are experienced up until the whole system is converted. The ALAS can for example be installed the Application for Abnormal Load Advice Certification module followed by Abnormal Load Permit Application. Conversion of the next module is done only after the first module is successful. It is applicable where the system is naturally divided into clear modules (Miller and Brabstone, 2005).

5.4.2.3.1 Advantages

- Risk is relatively moderate as it is only limited to the module being implemented

- Costs are also relatively moderate as the implementation is in phases for example with the ALAS, the ACAVC module can be implemented first whilst the rest of the modules remain manual without affecting the whole system.
- Users have relatively more time to cope with the changes to the system since the conversion is in phases.

5.4.2.3.2 Disadvantages

- Reverting back to the old system becomes complex with every new module of the system.
- It involves longer periods of training as there is always training for every module and users will always slow down the training by seeking clarity on earlier modules when they are being trained on the next module.
- It involves making several changes to the documentation which may prolong the project duration.
- Checking of completeness and correctness of datasets has to be repeated several times which is cumbersome.

5.4.2.4 Pilot Conversion

This is changeover implemented on part of the organization whilst the rest of the organization continues using the old system for example, ALAS new system can be implemented at VID first then at DoR later (Neeman and Sarlin, 2007). This applies to an organization that is departmentalized such that the operations of one department are localized to that department and only the outputs of one department become inputs of the other department. However, there are interface issues where organizational departments share data (Mallach, 2009). Risk is moderate as it is limited to the pilot site and not the whole organization.

5.4.2.4.1 Advantages

- Risk is limited to the pilot site such that if the system fails it will not affect the whole organization.
- System conversion is localized to the pilot site hence resources are focused on the pilot site therefore, more concentration on the department.

- Moderate costs are involved as it is only the pilot site that will be running two systems at a time.

5.4.2.4.2 Disadvantages

- There are interface issues where the pilot site shares data with other departments.
- Difficult to identify a site when the integration among departments is very high.

5.4.3 Factors Affecting Selection of Method Changeover

Factors affecting selection of method changeover refer to those issues that influence the decision in making a choice on the method to adopt (Kilganon, 1984).

	Revolution \longrightarrow Evolution		
Adoption type	Big Bang	Parallel Running	Phased adoption
Criteria			
<i>Needed "critical mass"</i>	High		Small
<i>Need for risk control</i>	Low		High
<i>Need for facilitation of the change.</i>	Low		High
<i>Pace of change over</i>	High		Low
<i>Local design needs</i>	Low		High
<i>User adaptation</i>	Difficult \longrightarrow Easy		

Figure 5.18: Changeover Methods Evolution

Source: (Mallach, 2009)

5.4.4 Chosen Changeover Method

The chosen method of changeover from the manual ALAS to the new computerised ALAS is phased changeover. This is so because ALAS can be divided into four major module which are:

- Application for Abnormal Vehicle Combination (AAVC),
- Application for Certification of Abnormal Vehicle Certification (ACAVC),
- Application for Abnormal Load Permit (AALP)
- Abnormal Load Permit (ALP)

Phased changeover method has moderate risk as the risk is localized to the module being converted only and not the whole system. If the module fails it is easy to revert back to the old system whilst some changes are being effected to the phase. It combines parallel changeover and direct changeover so the advantages with parallel and direct changeover methods so the advantages of the two are encapsulated in phased changeover (Mallach, 2009). Phased changeover will also make the users familiarize with the system easily as the user involvement goes step by step with the implementation.

5.5 Maintenance

Maintenance is the sum of activities required to provide a cost effective support to a system so that it survives in ever changing environment (Gannod, 2001). It is all about correction of errors and omissions that is essential to the system's usefulness (Whitten *et al*, 1996). Most of the errors and omissions are bugs that were not caught during testing in the construction and delivery phase. Maintenance activities are carried out before delivery referred to as pre-delivery activities, and even after delivery referred to as post-delivery activities. It is an on-going activity throughout the project and system life (Brown, 2004). Pre-delivery activities include; planning for the post-delivery activities, supportability of the system and logistics determination (Whitten *et al*, 1996). When changes are made to the system, a reciprocal maintenance has to be effected to the documentation. A well maintained documentation significantly accelerate the study phase when the system is due for an overhaul.

Maintenance is essential to every system for the following reasons:

- Systems always evolve as they are being used so maintenance has to be effected to suit the evolution
- Organisational changes may have an effect on the system's operations such that the system has to be maintained to be compatible to the organization changes
- Technological changes in terms of hardware and software may compel for the maintenance of the system for it to be useful in the changing environment.

According to Lientz and Swanson (1980), maintenance is subdivided into three categories which are corrective, perfective and adaptive maintenance. **Figure: 5.19** illustrate the maintenance process.

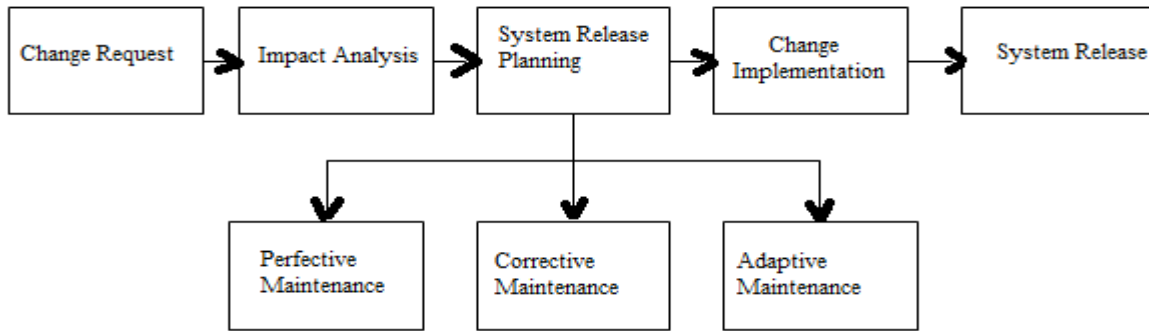


Figure 5.19: Maintenance Process

Source: (Binder, 1999)

5.5.1 Corrective Maintenance

This is changing the system in the way it meets the user requirements. The defects to be corrected emanate from design, coding and implementation of the system. So it is these areas of the system that needs to be corrected (Hughes and Cotterrell, 1996). Errors usually surface after installation and as such immediate maintenance is called to avoid interruptions to the daily operations of the system. Corrective maintenance mostly focuses on correcting errors in the system without adding anything new.

5.5.2 Adaptive Maintenance

This involves changes to the functionalities of the system to meet the user's needs. It implies modification of regardless of the fact that the system is working as expected and there is no fault or error in the system. These changes are caused by changes in the system environment and according to Lehman's Law number one of Software Evolution any system must be continually adapted or else it becomes progressively less satisfactory (Boris, 1990). Such changes will cause changes to the original system's set parameters therefore, the need for harmonization and implementation of new functionalities based on user requirements (Amman and Offutt, 2008). Adaptive maintenance is divided into two categories which are those caused by change of the rules and regulation of the country and those caused by other factors besides law for example technological changes (Boris, 1990). It is important to keep on checking on the validity of the system to changing environmental requirements.

5.5.3 Perfective Maintenance

Perfective maintenance involves making a better version of the already existing system (Shelly, and Rosenblatt2012). It encompasses facets such as inserting, deleting, extending, and modifying functions, rewriting documentation, improving performances, or improving ease of use. This is all so as to satisfy new requirements. This type of maintenance corrects errors that would have passed all the development phases undiscovered but will be discovered when the system is up and running even though the errors do not necessarily interfere with the operations of the system.

5.6 Recommendations

Having the ALAS project getting this far it was recommended to have the system installed and have it in operation for use by the MOTID. Furthermore, the following recommendations have to be observed as they play a pivotal role in the operations of system:

- An anti-virus be installed on all the computers where the system is going to run on. Viruses are a security threat that can result in the failure of the system if there is no anti-virus software to detect and clean viruses from the system.
- User passwords should be the user's secret never to be availed to anybody else and the password should regularly be changed.
- Users should always alert the Systems Administrator of any mishap with the system so that if there are any errors with the system, the problem is attended to before it interrupts the operations of the whole system.
- Management should regularly check the validity of the system by scrutinizing the reports generated by the system.
- ALAS makes use of MOTID security items such as stamp and seal to authenticate the certificates such as abnormal load advice certificate and the abnormal load permit which are vulnerable to being counterfeited so it is important to restrict access to the system through physical and software security features.
- It is highly recommended that management leave room for system improvement so that the system does not end here but better versions of the system be improved by allowing innovation from the system users as management accepts any new ideas concerning system improvement from users.

- Time and again a system performance should be reviewed by making enquiries with all stakeholders so that their feedback can be taken into consideration to effect perfective and adaptive maintenance.
- There is need to keep abreast of all the environmental changes that may affect the system.

5.5 Constraints

Constraints refers to all the elements that hindered the development of the system as per plan (Kolawa and Huizinga, 2007). ALAS, just like any other systems development project was constrained with time. Furthermore, ALAS project development was hindered by lack of financial resources. Data gathering involved a lot of movement from one department of MOTID to the other which involved money for movement as the departments are geographically spaced for example, the nearest VID depot from MOTID head office is 5 Kilometers which added up to 10 Km to and fro. Fuel to travel to VID required some finances. To get hold of the staff to make enquiries about the system during the system study phases required to make appointments of which not all appointments were honoured at the agreed time because of work thereby affecting the project duration as it was automatically be extended.

5.6 Conclusion

The system was successfully implemented and tested. The set objectives were revisited during system testing so as to see if they were met and it came out that they were indeed being satisfied. Furthermore, the users were trained on how to use the system and to aid the users during use, there is a user manual for that; APPEDIX 3. However, the system still needs maintenance as it exist in an environment that is dynamic and as such system maintenance has to continue after installation. Having come this far, the project is deemed successful.

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Appendix A: User Manual

1.0 System Login and Logout

1.1 System login

The system is accessible via a web browser. To get to the login page you enter the web address of the system. If the connection is successful the login page in **Figure A1** is displayed. To login in, fill in the form with your correct system credentials. In the case of a wrong password or username, the system displays an error message in the area annotated 1 in **Figure A1**.

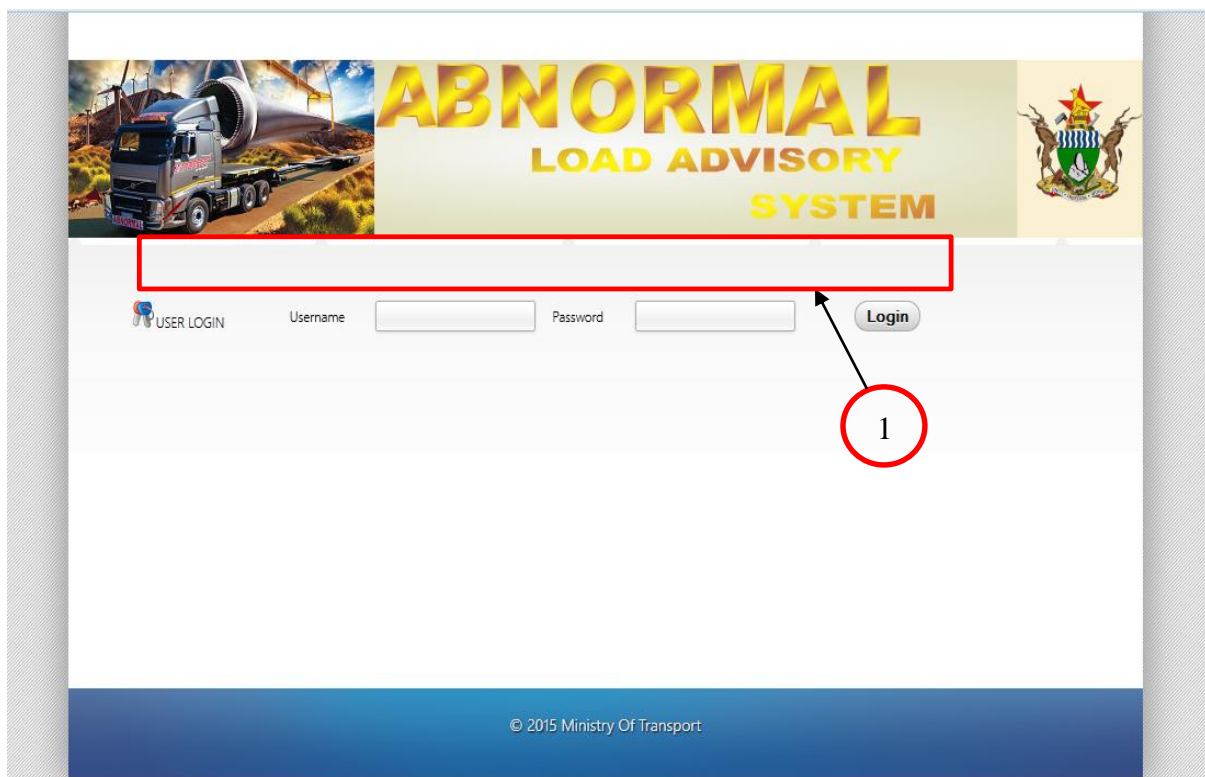


Figure A1: Login page

After successful log in, the main page that applies to your system role is displayed.

1.2 System Logout

To logout you click on the Account link, situated on the right side of the navigation menu, a submenu is displayed. On the submenu click logout.

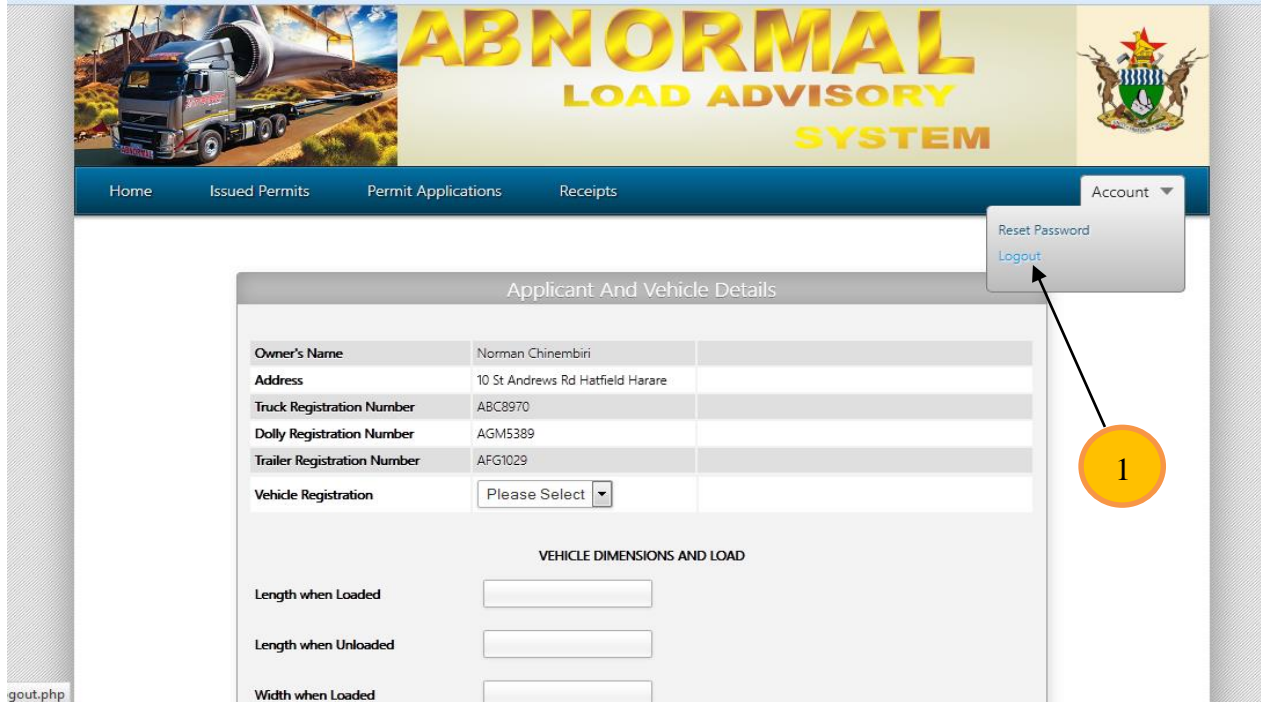


Figure A2: System Logout

1.3 VID Clerks

Figure A3 shows the home page that is displayed after successful login.

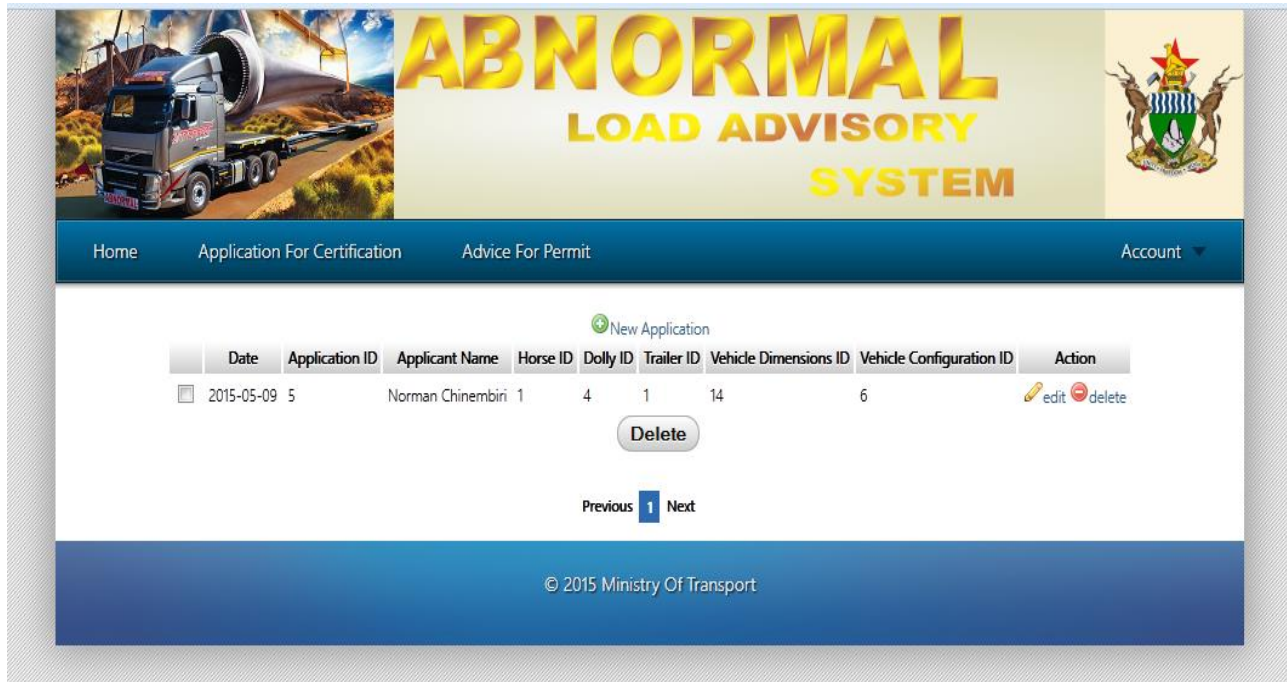


Figure A3: Home page of Clerks

Figure A3 shows the Home Page for VID clerks. It contains links to process applications for Certification of Abnormal Vehicle Combinations and Abnormal Load Permits. To create a new application for certification of Abnormal Vehicle Combination click on New Application. To edit an application click on the edit link adjacent to the application. To delete an application Click on the Delete link adjacent to the application.

1.3.1 Application for Certification Of Abnormal Vehicle Combination

Figures A4 and A5 (shown overleaf) show the application form for Certification of Abnormal Vehicle Combination. Fill out the form with all the necessary details and Click **Next**. After clicking next the form in **Figure A6** is displayed.

The screenshot displays the 'ABNORMAL LOAD ADVISORY SYSTEM' interface. At the top, there is a banner with a truck and the system title. Below the banner is a navigation bar with links: Home, Application For Certification, Advice For Permit, and Account. The main content area is titled 'Application For Certification Of Abnormal Load Combination' and contains the following form fields:

- Operator:
- COMBINATION UNITS
- Horse Registration Number:
- Dolly Registration Number:
- Trailer Registration Number:
- Vehicle Image: No file selected.
- VEHICLE DIMENSIONS
- A:
- B:

Figure A4: Application for Certification Of Abnormal Load Combination Form (Part 1)

J

K

L

M

N

O

P

Q

R

S

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Figure A5: Application for Certification of Abnormal Load Combination Form (Part 2)

Home Application For Certification Advice For Permit Account

Vehicle Measurements

Unladen Weight (Steer)

Unladen Weight (Drive)

Unladen Weight (Dolly)

Wheels: Single, Dual or 4 in line (Drive)

Wheels: Single, Dual or 4 in line (Dolly)

Tyre Size (Steer)

Tyre Size (Drive)

Tyre Size (Dolly)

Tyre Pressure (Steer)

Tyre Pressure (Drive)

Tyre Pressure (Dolly)

Figure A6: Application for Certification Of Abnormal Load Combination Form (Part 3)

Figure A6 shows a section of the application, which takes the physical vehicle measurements. Fill out all the fields and click **Submit**. After clicking Submit you will be presented with a confirmation page (**Figure A7**) notifying you that the application was successful.

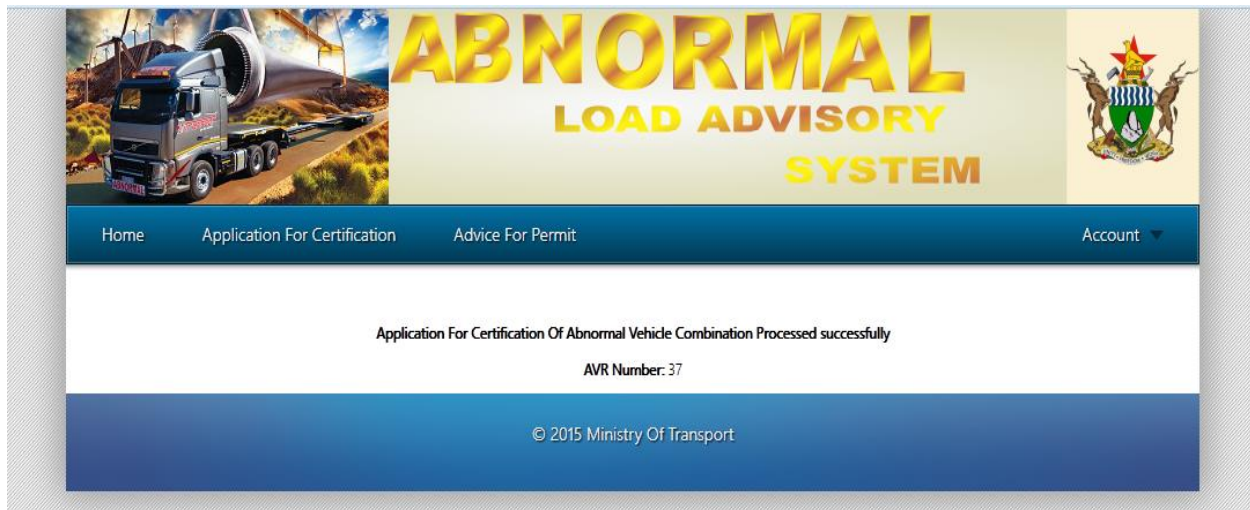


Figure A7: Application for Certification of Abnormal Load Combination Confirmation Page

To view applications for certification of abnormal load combination click Applications on the navigation menu and click the view link (marked **a** in **Figures A8**) on the application you want to view. The application details are presented as shown in **Figures A9 and A10**

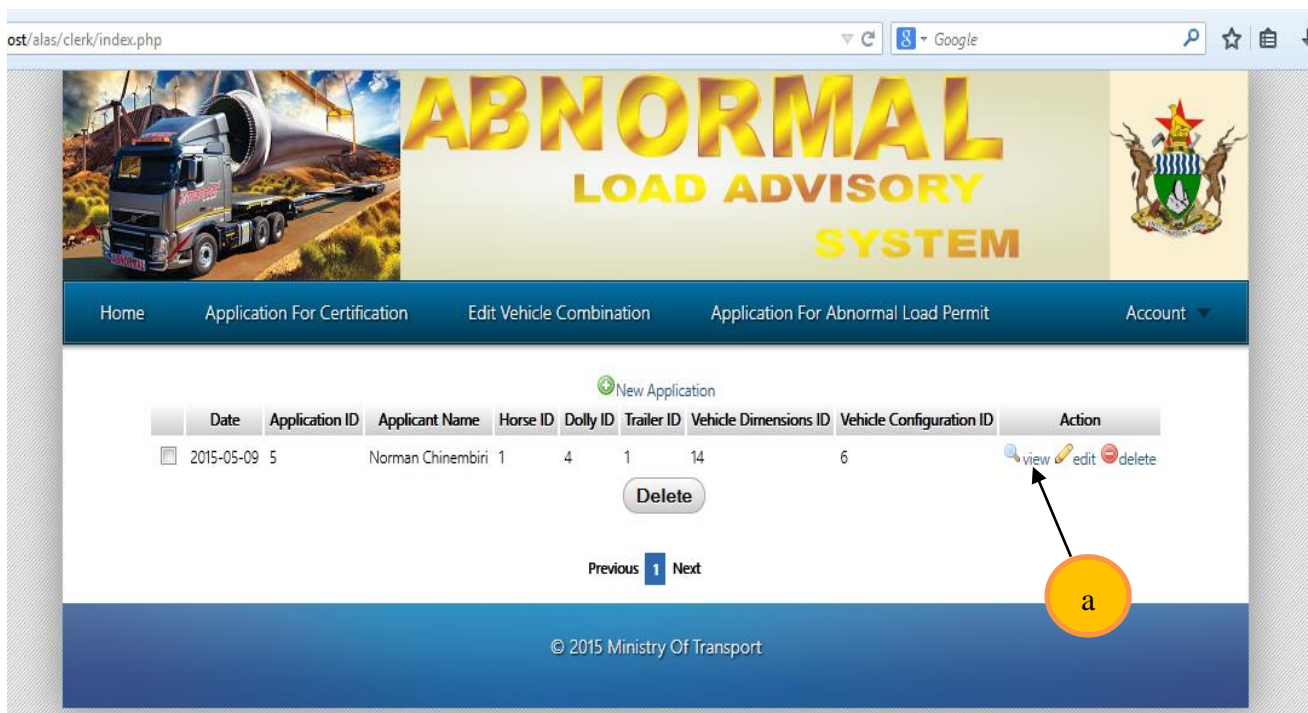


Figure A8: Application for Certification of Abnormal Load Combination View Link

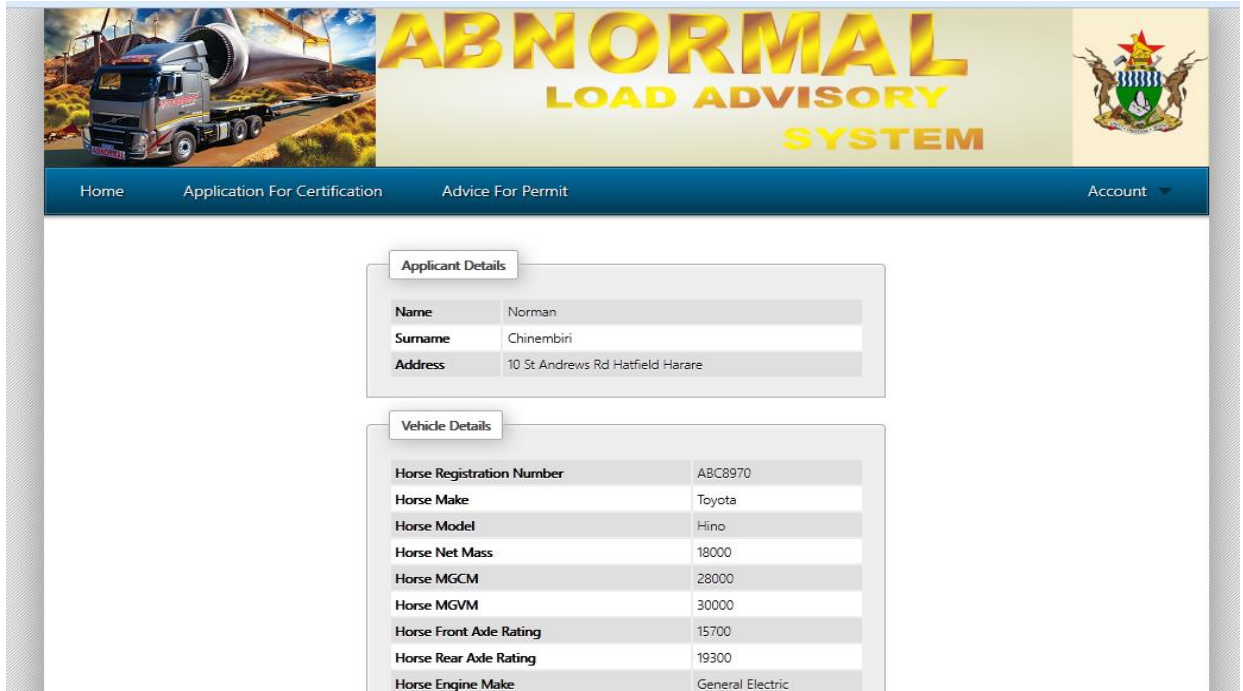


Figure A9: Application for Certification of Abnormal Load Combination View Page (Part 1)

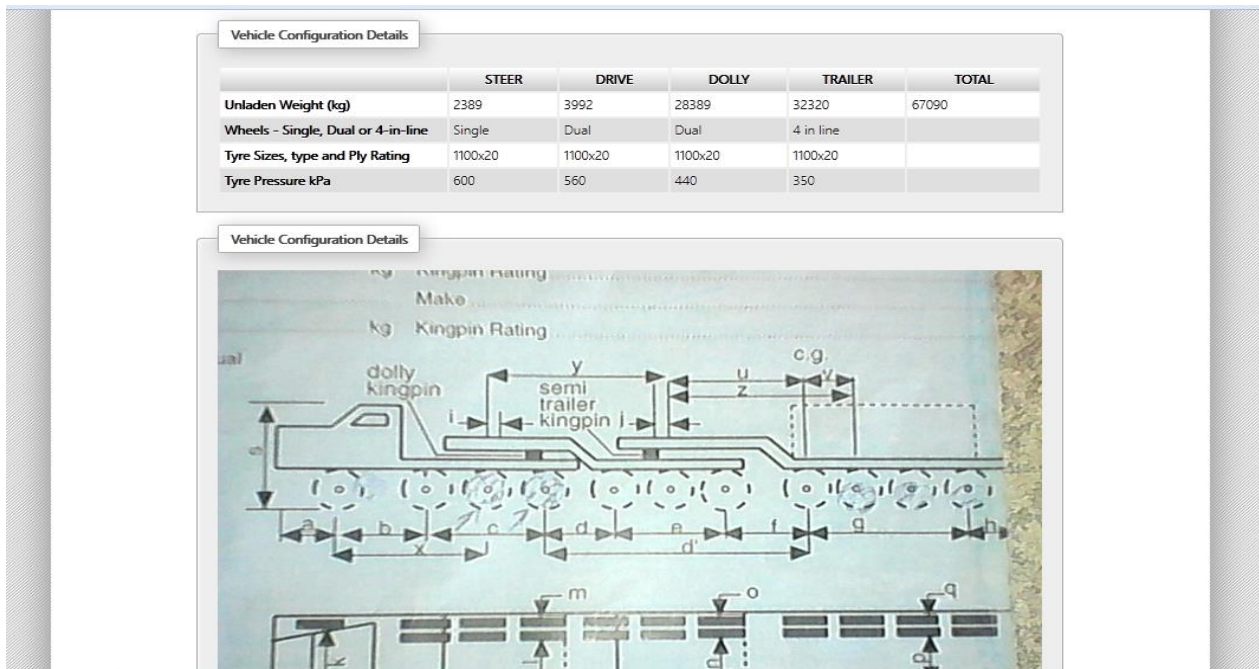


Figure A10: Application for Certification of Abnormal Load Combination View Page (Part 2)

1.3.2 Application For Abnormal Load Permit

To make an application for an Abnormal Load Permit click Application for Abnormal Load Permit on the navigation menu. A list of Advices for Certification Of Abnormal Vehicle is displayed (Figure A11).

Advice ID	Date	AVR Number	Applicant Name	Maximum Payload	Maximum Gross Combination Mass	Action
1	2015-05-13	1	Norman Chinembiri	4540	71630	Apply For Permit

Figure A11: Application for Abnormal Load Permit

Click on the apply for permit link adjacent to the advice for which you intend to make an application. The link is highlighted within the red rectangle in Figure A11. Figure A12 and A13 shows an example of an application for Abnormal Load Permit.

Figure A12: Application for Abnormal Load Permit (Part 1)

Figure A13: Application for Abnormal Load Permit (Part 2)

After filling out the form click on submit at the bottom of the form (highlighted in red in **Figure A13**). A confirmation page shown in **Figure A14** is displayed.

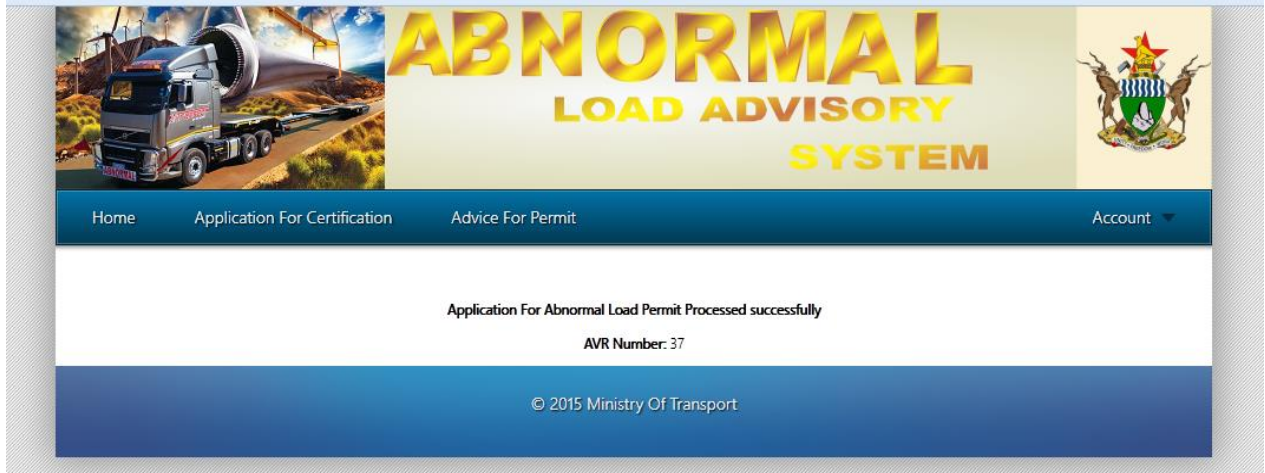


Figure A14: Application for Abnormal Load Permit Confirmation Page

1.3.3 Changing Units in an Abnormal Vehicle Combination Certification

On the home page (shown in **Figure A15**) a list of applications is shown. To change an application's unit combination click on the edit link (bounded in red in **Figure A15**).

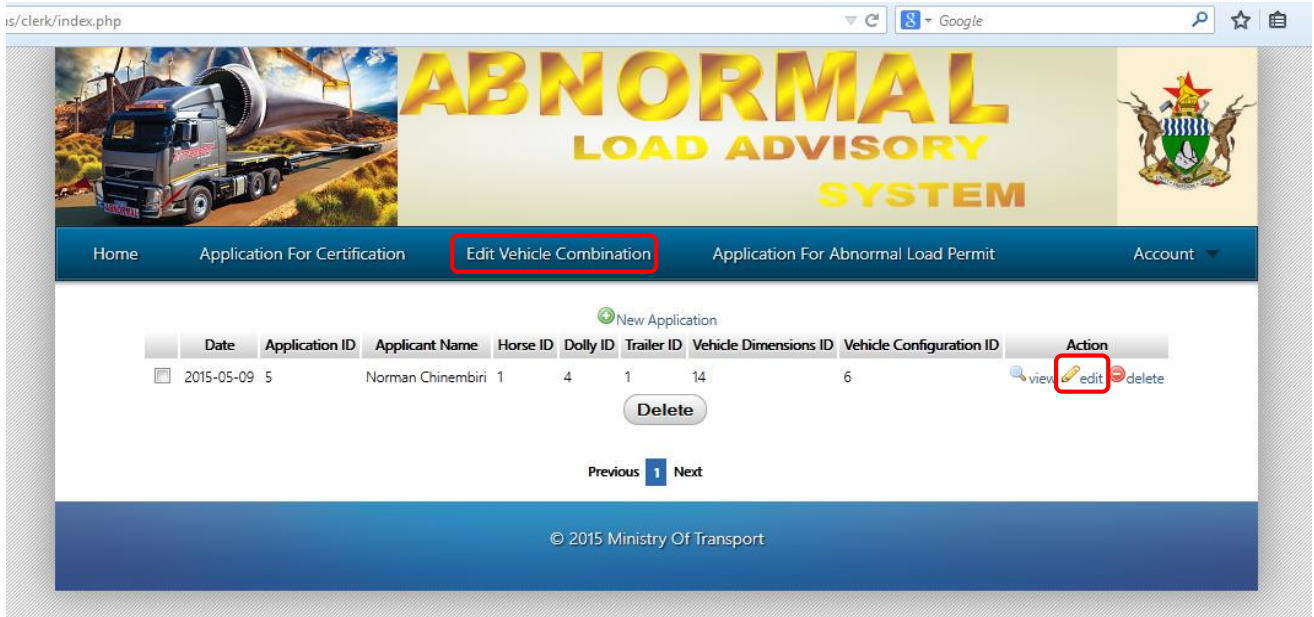


Figure A15: VID Clerk Home Page

The page shown in **Figure A16** will be displayed after clicking edit.

Application For Certification Of Abnormal Load Combination

Operator:

COMBINATION UNITS

Horse Registration Number:

Dolly Registration Number:

Trailer Registration Number:

Vehicle Image: No file selected.

VEHICLE DIMENSIONS

A:

B:

Figure A16: Change Vehicle Combination Units (Part 1)

as/clerk/update_app.php?id=1

J:

K:

L:

M:

N:

O:

P:

Q:

R:

S:

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Figure A17: Change Vehicle Combination Units (Part 2)

Change the vehicle units by modifying the unit registration number fields. After that you enter new vehicle dimensions for the new combination and click next button.

The screenshot shows the 'ABNORMAL LOAD ADVISORY SYSTEM' website. The header includes a navigation menu with 'Home', 'Application For Certification', 'Edit Vehicle Combination', 'Application For Abnormal Load Permit', and 'Account'. The main content area is titled 'Vehicle Measurements' and contains the following form fields:

- Unladen Weight (Steer) - Text input field
- Unladen Weight (Drive) - Text input field
- Unladen Weight (Dolly) - Text input field
- Unladen Weight (Trailer) - Text input field
- Wheels: Single, Dual or 4 in line (Drive) - Dropdown menu (Please Select)
- Wheels: Single, Dual or 4 in line (Dolly) - Dropdown menu (Please Select)
- Wheels: Single, Dual or 4 in line (Trailer) - Dropdown menu (Please Select)
- Tyre Size (Steer) - Dropdown menu (Please Select)

Figure A18: Change Vehicle Combination Units (Page 2 – part 1)

This screenshot shows the continuation of the 'Vehicle Measurements' form. It includes the following fields:

- Wheels: Single, Dual or 4 in line (Drive) - Dropdown menu (Please Select)
- Wheels: Single, Dual or 4 in line (Dolly) - Dropdown menu (Please Select)
- Wheels: Single, Dual or 4 in line (Trailer) - Dropdown menu (Please Select)
- Tyre Size (Steer) - Dropdown menu (Please Select)
- Tyre Size (Drive) - Dropdown menu (Please Select)
- Tyre Size (Dolly) - Dropdown menu (Please Select)
- Tyre Size (Trailer) - Dropdown menu (Please Select)
- Tyre Pressure (Steer) - Text input field
- Tyre Pressure (Drive) - Text input field
- Tyre Pressure (Dolly) - Text input field
- Tyre Pressure (Trailer) - Text input field

A 'Submit' button is located at the bottom of the form. The footer of the page reads '© 2015 Ministry Of Transport'.

Figure A19: Change Vehicle Combination Units (Page 2 – part 2)

Fill out the form and click on submit button. The page in **Figure A20** will be displayed showing a confirmation for the unit combination update.



Figure A20: Vehicle Unit Combination Update confirmation page

1.4 VID Inspector

After successful login the first page is the home page. The home page contains links to other pages that are important to the VID inspector. **Figure A20** shows the home page for the VID Inspector. The page shows a list of all the applications processed by the VID Clerk awaiting certification from the VID Inspector.

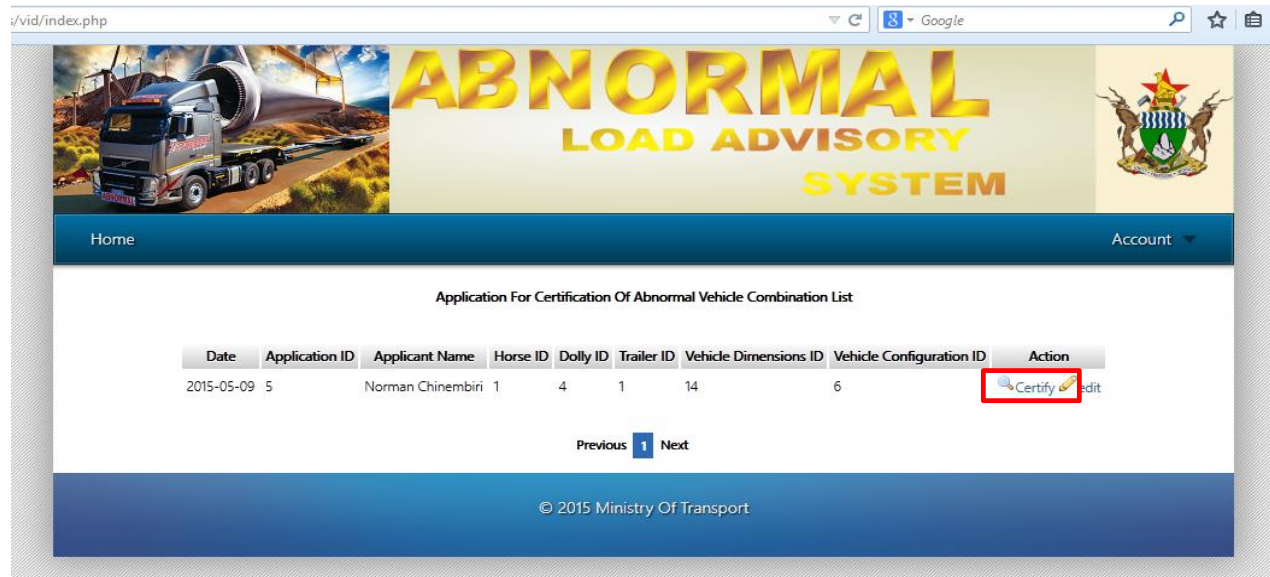


Figure A20: VID Inspector home page

To certify an application click on the certify link (highlighted in red in **Figure A20**). The page in **Figures A21 and A22** will be displayed.

Applicant Details	
Name	Norman
Surname	Chinemhiri
Address	10 St Andrews Rd Hatfield Harare

Vehicle Details	
Horse Registration Number	ABC8970
Horse Make	Toyota
Horse Model	Hino
Horse Net Mass	18000
Horse MGCM	28000
Horse MGVM	30000
Horse Front Axle Rating	15700
Horse Rear Axle Rating	19300
Horse Engine Make	General Electric
Horse Engine Model	Turbo
Horse Power at Clutch	35000
Dolly Registration Number	AGM5389
Dolly Make	Toyota
Dolly Axle Rating	16000
Dolly Kingpin Rating	32000
Trailer Registration Number	AFG1029
Trailer Make	Nissan
Trailer Net Mass	25000

Figure A21: Certify Application (Part 1)

Vehicle Configuration Details																													
<table border="1"> <thead> <tr> <th colspan="5">Dimensions (mm)</th> </tr> </thead> <tbody> <tr> <td>A: 0</td> <td>B: 0</td> <td>C: 0</td> <td>D: 0</td> <td>E: 0</td> </tr> <tr> <td>F: 0</td> <td>G: 0</td> <td>H: 0</td> <td>I: 0</td> <td>J: 0</td> </tr> <tr> <td>K: 0</td> <td>L: 0</td> <td>M: 330</td> <td>N: 0</td> <td>O: 0</td> </tr> <tr> <td>P: 550</td> <td>Q: 713</td> <td>R: 0</td> <td>S: 0</td> <td></td> </tr> </tbody> </table>					Dimensions (mm)					A: 0	B: 0	C: 0	D: 0	E: 0	F: 0	G: 0	H: 0	I: 0	J: 0	K: 0	L: 0	M: 330	N: 0	O: 0	P: 550	Q: 713	R: 0	S: 0	
Dimensions (mm)																													
A: 0	B: 0	C: 0	D: 0	E: 0																									
F: 0	G: 0	H: 0	I: 0	J: 0																									
K: 0	L: 0	M: 330	N: 0	O: 0																									
P: 550	Q: 713	R: 0	S: 0																										
<input type="button" value="Certify"/>		<input type="button" value="Back"/>																											

Figure A22: Certify Application (Part 2)

To certify the application click on certify. A certification confirmation page will be displayed.

Figure A23 shows the confirmation page.

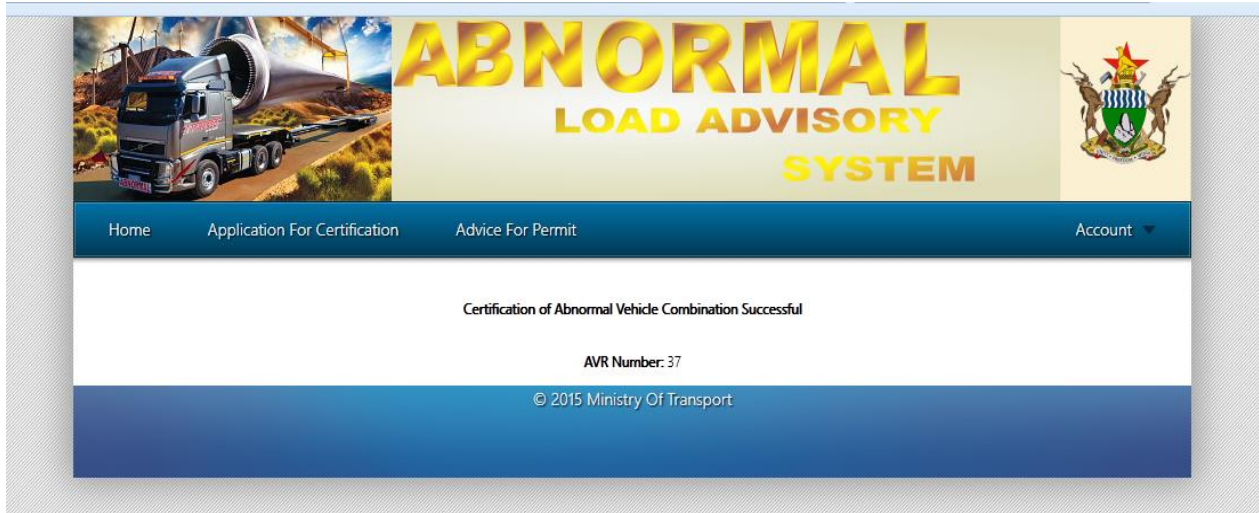


Figure A23: Certification Confirmation Page

1.5 Bridges Technician

After successful login the page in **Figure A24** is displayed for the users with the bridge technician role.

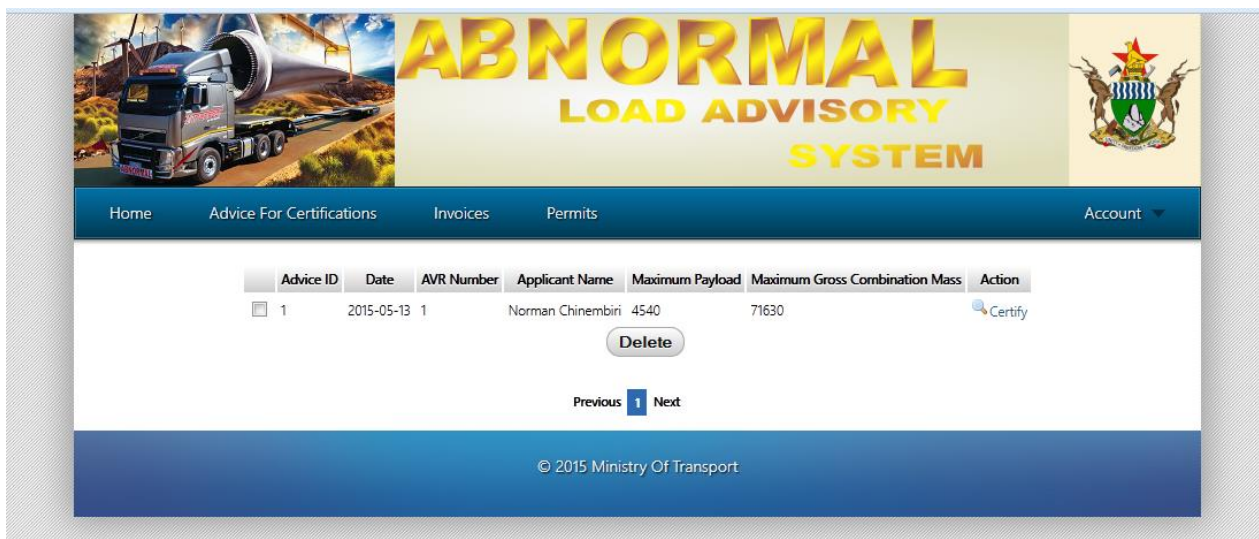


Figure A24: Bridges Technician Home Page

To certify view and certify an application click on the Certify Link adjacent to the application in the list. The page displayed in **Figure A25** is displayed. It shows the maximum permissible massloads and tyre pressures. To certify the application click on the Certify button.

Vehicle Number: **ABC8970** in combination with Dolly Number: **AGM5389** and semi trailer Number: **AFG1029** has been analysed and entered on the Register of Abnormal Vehicles, with the following: -

(1) The gross axle group massloads, cold tyre inflation pressures and gross combination masses shall not exceed the values in the following table:

Axle Group	Steer	Drive	Dolly	Trailer	GCM
Legal Load (kg)	8000	18000	16000	24000	66000
Load at ESWM 3750 (kg)	8770	16960	16960	32100	74790
Max. Permitted Load (kg)	11330	19300	16000	25000	71630
ESWM (kg) at Max. Permitted Load	5000	4276	3534	2464	
Tyre Pressure (kPA)	425	436	436	520	

(2) The sum of the steer and drive groups shall not exceed **30630 kg**.
 The gross combination shall not exceed **71630 kg**.
 The payload shall not exceed **4540 kg**.

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Figure A25: Advice For Certification of Abnormal Load Vehicle

After clicking certify the confirmation page in **Figure A26** is displayed.

Advice For Certification Successful
 AVR Number: 37

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Figure A26: Advice For Certification of Abnormal Load Vehicle Confirmation Page

1.5.1 Abnormal Load Permits

1.5.1.1 Invoice issuance

To issue an invoice for a particular permit application first click on the Issue Invoice link (highlighted 1 in **Figure A27**) on the navigation menu. A page displaying a list of applications is displayed. **Figure A27** shows a list of permit applications that is displayed.

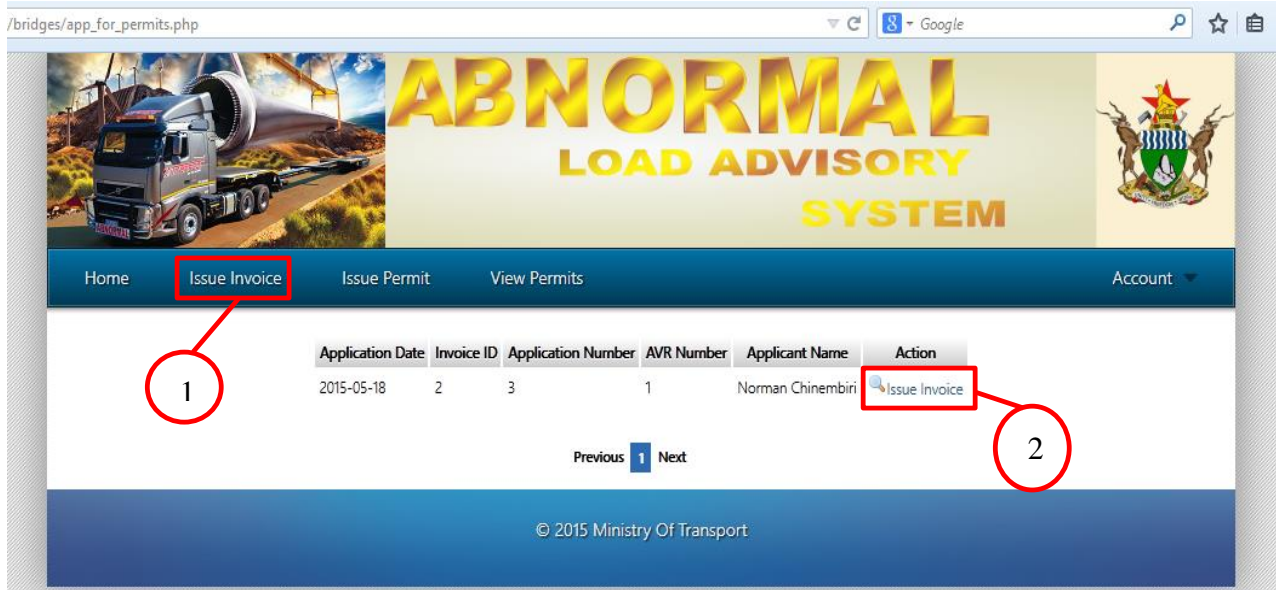


Figure A27: Application for Abnormal Load Permit List

To issue an invoice click on the Issue Invoice link (highlighted 2 in **Figure A27**) adjacent to the permit application. The invoice details page in **Figure A28** is displayed.

Invoice Details		
Invoice Number	2	
Date	2015-05-21	
Owner's Name	Norman Chinembiri	
Address	10 St Andrews Rd Hatfield Harare	
Truck Registration Number	ABC8970	
AVR Number	1	
Source	Harare	
Destination	Bulawayo	
Via	Gweru	

Description	Actual ESWM	Cost(\$)
Abnormal Vehicle Registration Fee		50
Steer	4517	43.00
Drive	4506	43.00
Dolly	5000	64.50
Trailer	4276	34.40
Total		234.90

[Print](#)

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Figure A28: Invoice Details Page

To print the invoice click on the Print Button.

1.5.1.2 Permit issuance

Abnormal Load Permits are issued upon presentation of the receipt showing the payment of the load cost. The receipt is captured in the system

To issue a permit click on the Issue Permit link (highlighted in **Figure A29**).

Please Enter Invoice Number:

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Figure A29: Capture Permit Receipt

To capture a receipt you first enter the invoice number for the application. The invoice details will be displayed immediately below the invoice input field with details of the invoice.

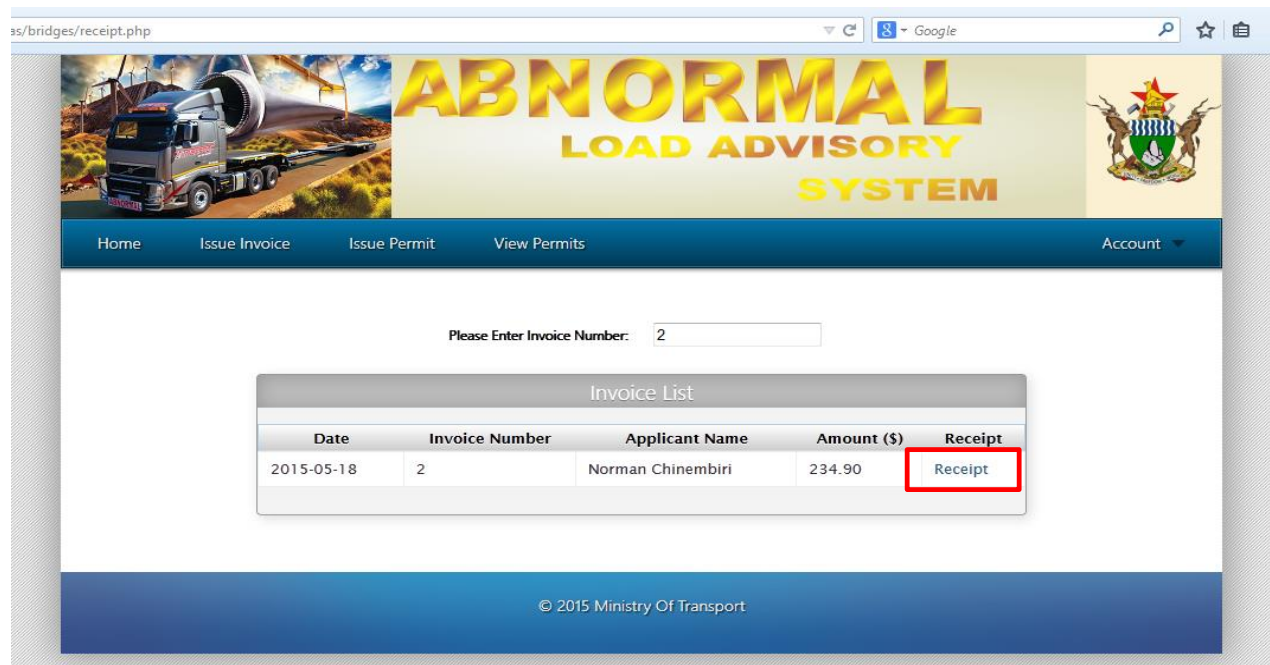


Figure A30: Invoice Details

As a second step click on the receipt link highlighted in **Figure A30**. The page in **Figure A31** is displayed. Enter the receipt number on that screen and click on capture.

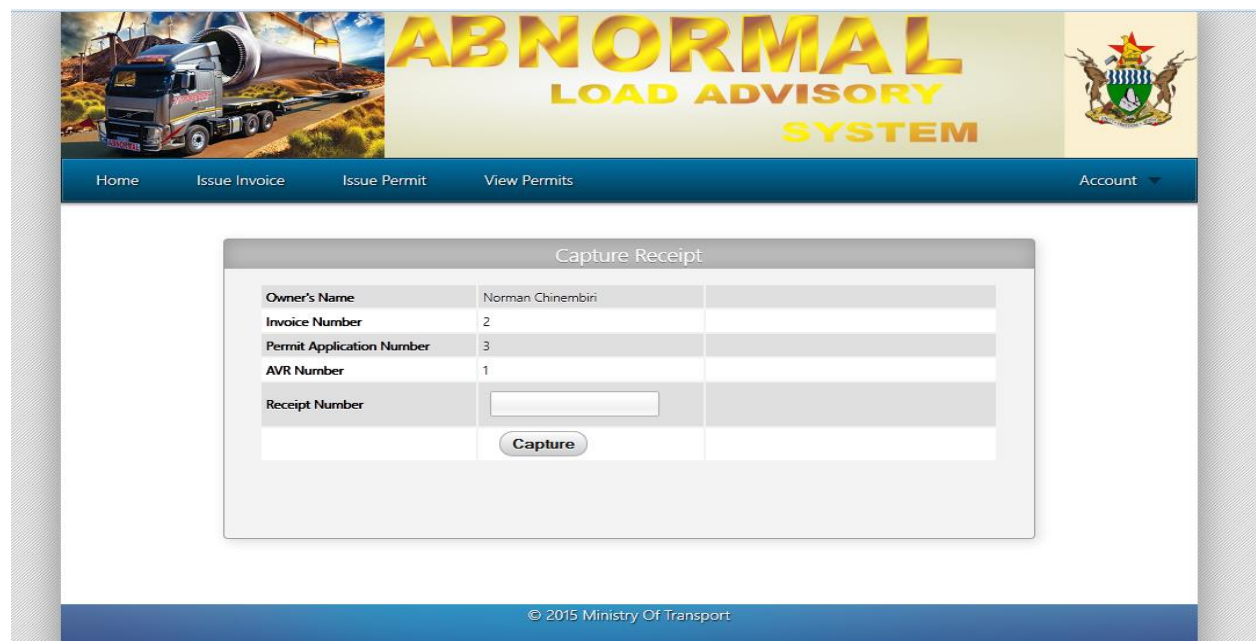


Figure A31: Receipt Input Page

A confirmation page shown in **Figure A32** will be displayed.

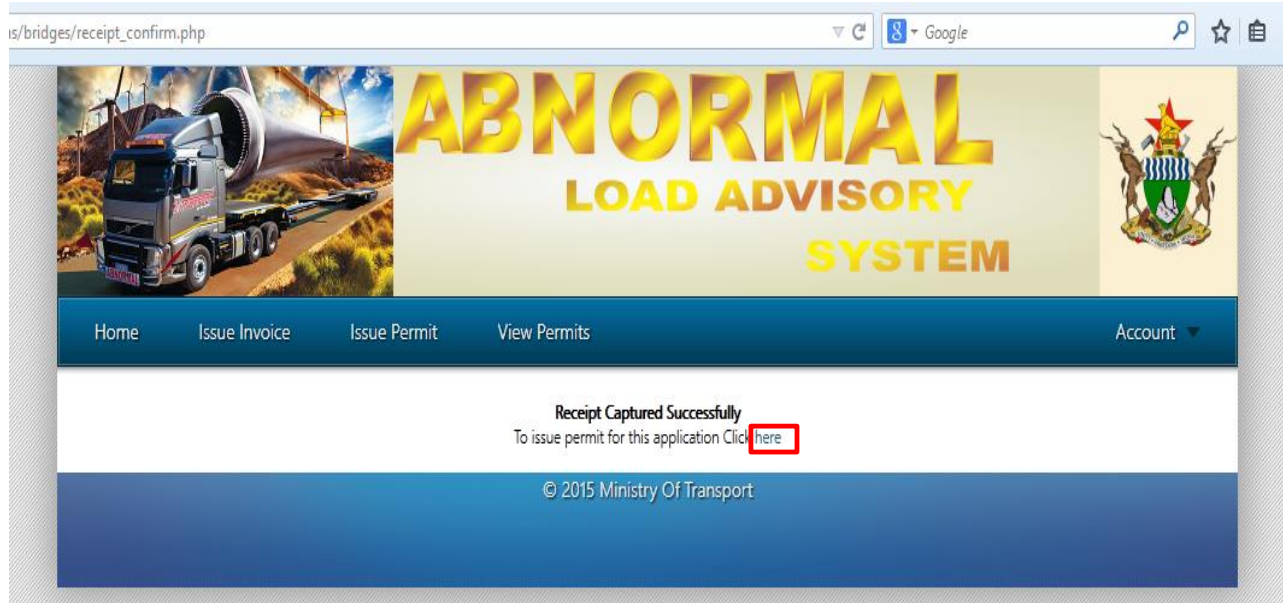


Figure A32: Receipt Input Confirmation Page

To issue the permit for the application click on the link highlighted in **Figure A32**. **Figure A33** shows the permit for the application that will be issued.



GOVERNMENT OF ZIMBABWE

ABNORMAL LOAD PERMIT

The minister of Transport hereby grants exemption from the provisions of section 4 of the Road Traffic (Axle Loading) Regulations, 1977, and from the provisions of sections 4, 5 and 6 of the Roads and Road Traffic (Construction, equipment and use) Regulations, 1972, for the movement of the vehicle and load described on the application form, over the route specified during the period requested, subject to the following conditions.

Date: 2015-05-21	Owner's Name: Norman Chinembiri	AVR No: 1
Truck Reg No: ABC8970	Dolly Reg No: AGM5389	
Trailer Reg No: AFG1029		
Source: Harare	Destination: Bulawayo	Via: Gweru
Date of Movement: 2015-05-20 to 2015-05-22		
A. The gross axle massloads shown in the application shall not be exceeded		
Steer: 7500	Drive: 21000	Dolly: 28000
		Trailer: 30000
B. Cold inflation tyre pressures must not exceed (kPa):-		
Steer: 425	Drive: 436	Dolly: 436
		Trailer: 520
C. The following speeds must not be exceeded -		
Urban:	Rural:	Over Bridges:
D. Standard permit conditions: 1-11 Inclusive applied		
E. The Gross massload on the drive axle group must not be less than 20 per cent of the gross combination mass for an articulated trailer or 15 percent for an independent trailer.		
F. Escort Requirements:		
G. Warning Sign Requirements -		
(i) Bright and red flags at least 600 mm x 600 mm attached to vertical poles mounted on the extremities of the vehicle		
(ii) Warning boards at least 2 000mm wide 300mm high and bearing the word "ABNORMAL" in red letters 200mm high on a white background to be mounted front and rear		
(iii) A flashing amber beacon light to be fitted to the vehicle and illuminated whenever the vehicle is on the road.		

Figure A33: Abnormal Load Permit

1.6 Management

After successful login the page in **Figure A34** is displayed for the users with the manager role.

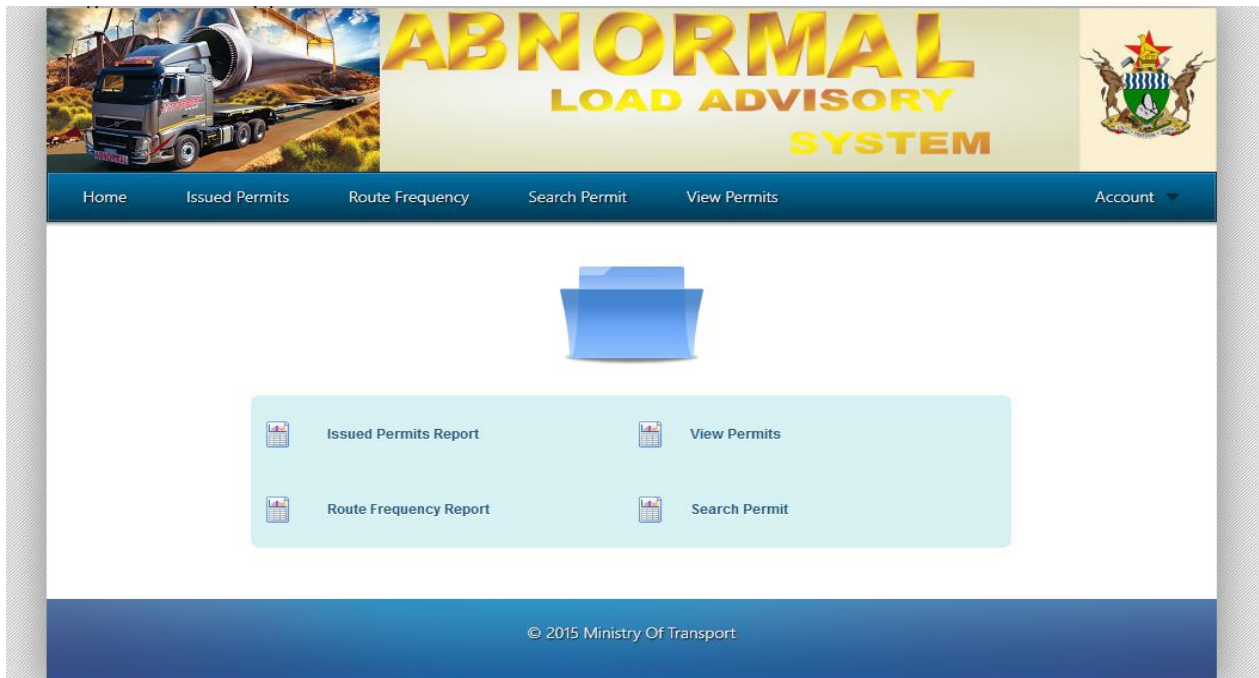


Figure A34: Home page for management

To view a particular report click its link in the list shown in the content area.

Figure A35 shows the page that is displayed after clicking on the Route Frequency Report Link.

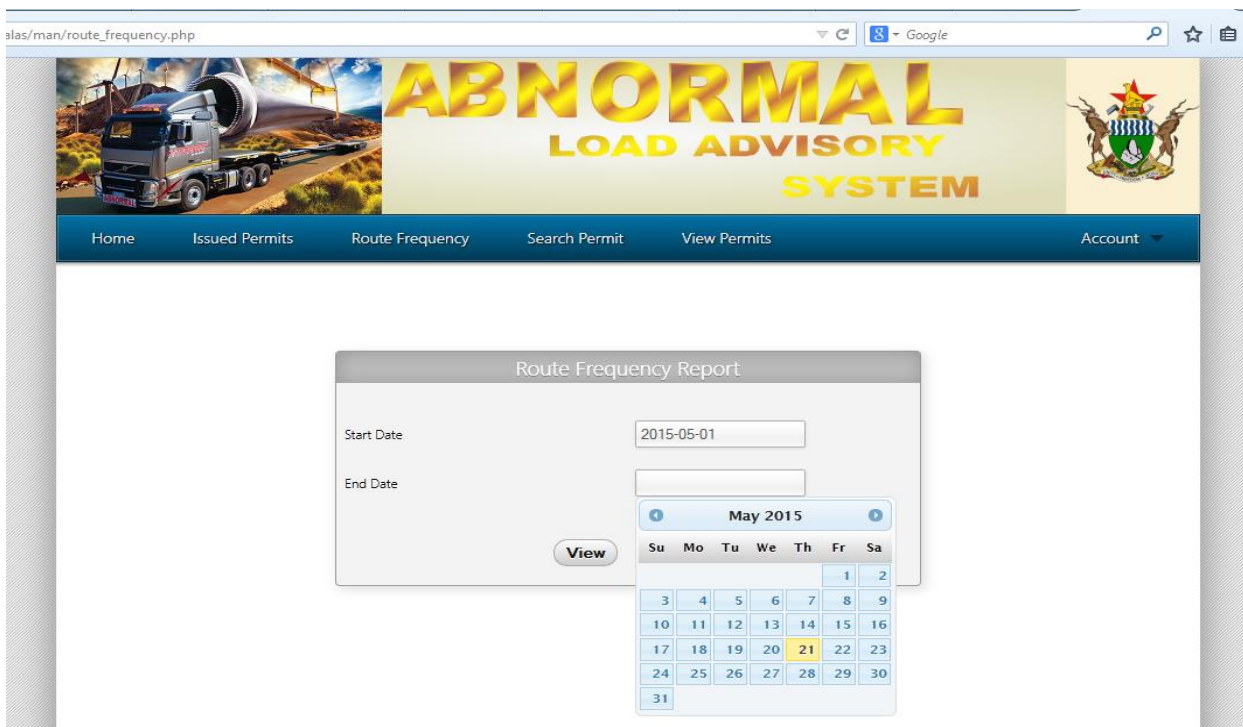


Figure A35: Route Frequency Report (Period Entry Form)

Select the start date and end date from the date pickers and click view

Figure A36 shows the report that will be displayed

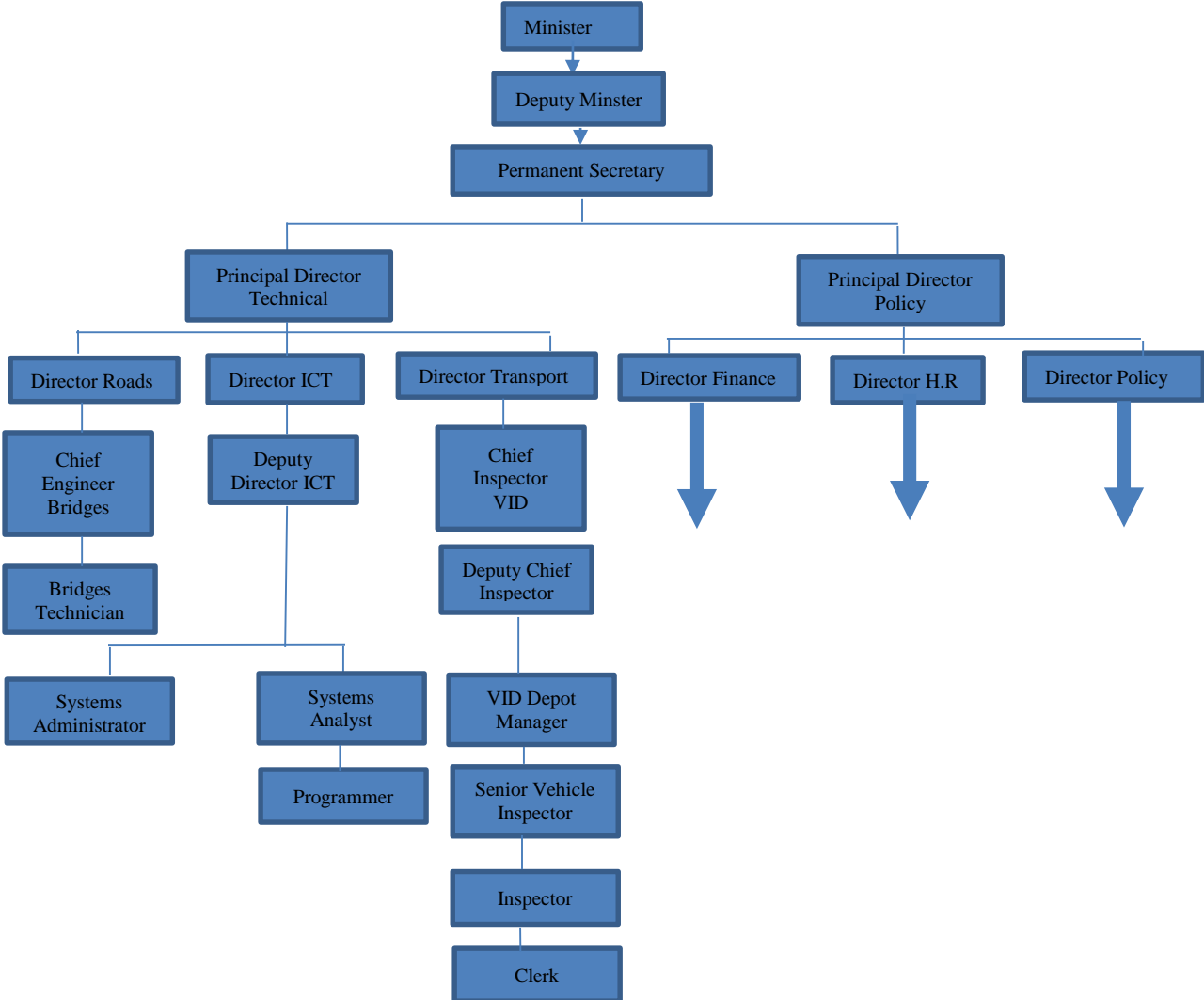
The screenshot shows a web browser window with the URL `/man/route_frequency1.php`. The page features a header with the text "ABNORMAL LOAD ADVISORY SYSTEM" and the Zimbabwean coat of arms. A navigation menu includes "Home", "Issued Permits", "Route Frequency", "Search Permit", "View Permits", and "Account". The main content area displays a report titled "Route Frequency from: 2015-05-01 to 2015-05-21".

Route No	Source	Destination	Via	Frequency: Number of Vehicles Using Route
2	Harare	Bulawayo	Gweru	1

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Figure A36: Route Frequency Report

APPENDIX B: ORGANOGRAM



APPENDIX C: QUESTIONNAIRE

This paper is a questionnaire seeking your responses in order to gather information pertaining to Abnormal Load Advisory System (ALAS). The information gathered is confidential and shall not be used for any other purposes other than that of studying the ALAS. So please feel free to respond the questionnaire.

(NB. Do not write your name or any personal identification particulars on the questionnaire. The questionnaire consist of 10 questions)

- Answer all the questions
- Give accurate details on all answers and be open to express your views.
- Return the questionnaire to the I.T. Manager (Mr. Magombeyi) by 15 March 2015

****Tick where appropriate and fill in where spaces are provided.*****

1.) How long have you known about Abnormal Load Advisory System (ALAS)?

1 Year or Less 1-3 Years more than 3 Years

2.) How frequent do you use the ALAS?

Every day at least once a week at least once a month

At least once quarterly at least once a year Never

3.) I what capacity do you use ALAS?

MOTID Staff Operator/Client Other Stakeholder

4.) How do you rate the time it takes for an operator to obtain an abnormal load permit from the time of certification application?

Too long Reasonable Alright

5.) Do you find the calculations of vehicle load limits consistent all the times?

Yes No

6.) What problems are you experiencing with the ALAS

7.) How do you suggest the problems be solved if there are any problems you have highlighted? _____

8.) How long does it take to have all the regularities (in terms of obtaining an abnormal size permit) in place so that an abnormal load vehicle starts to move? _____

9.) Are you happy with the current system

Yes

No

10.) If the response to question 9 is NO, may you suggest ways of improving the making the system better _____

End of Questionnaire.

APPENDIX D: INTERVIEW QUESTIONS CHECKLIST

Sample of the interview questions conducted by Mr. George Magombeyi

Interview script for Abnormal Load Advisory System (ALAS)

Q1 What do you think about the abnormal load advisory system.

Q2 Can you outline all the tasks that you perform?

Q3 Do you have any form of feedback that you give to operators besides permit and advice for certification?

Q4 Is your management feedback requirements satisfied by your current study format?

Q6 Is your feedback to management timely delivered, is it delivered when needed to? If not do you know why not?

Q7 Does the current system format give you enough control to effectively and efficiently perform your duties?

Q8 When working with the system which areas do you find time consuming and cumbersome?

Q9 If different members of staff are to make some abnormal load calculations such as ESWM do they come up with the same result?

Q10 If answer to Q9 is NO then why could it be so?

Q11 Is the current system delivering as per your expectations?

Q12 How do you feel about computerizing the system?

APPENDIX E: OBSERVATION SCORE SHEET

Date.....

Time.....

Place.....

OBSERVATION POINTS

- Incidents that are a result of inefficient system

- Manual ALAS reports not generated at all

- Activities that are routine and cumbersome

- Security facilities provided for by the manual system

Conclusion:

APPENDIX F: SNIPPET OF CODE

Login Code

```
<?php
    if(isset($_GET['msg']))
        {$msg = $_GET['msg'];}
    else
        {$msg = "";}

?>

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>User Login</title>
<link rel="stylesheet" href="../css/style_sheet.css" />
<link rel="stylesheet" href="css/menu.css" />
<link rel="stylesheet" href="../css/form.css" />
<link rel="stylesheet" href="../css/jquery.ui.all.css" />
<script src="../js/jquery-1.9.1.js"></script>
<script src="../js/jquery-ui-1.10.3.custom.js"></script>
<script>
    function validate_inputs()
    {
        if(document.getElementById("username").value == "")
            {
                $("#dialog").attr("title", "Validation Information").text("Please
enter username").dialog()
            } else if(document.getElementById("password").value == "")
            {
```

```

        $("#dialog").attr("title","Validation Information").text("Please
enter password").dialog()
    } else
    {
        document.getElementById("login").submit();
    }
}
</script>
</head>

<body>
<div id="main_cont" class="container">
<div id="spacer" style="height:100px; width:980px">
</div>
<div id="header" style="background-image:url(../images/header_2.png); width:980px;
height:150px;">
</div>
<div id="login_frame" class="login_frame">
<form action="do_login.php" method="post" id="login">
<table width="980px" height="150px" ;="">
<tbody>
<tr>
<td colspan="6" align="center"><font color="#FF0000"><?php echo $msg ?></font></td>
</tr>
<tr>
<td width="203">&nbsp;</td>
<td width="65">&nbsp;</td>
<td width="154">&nbsp;</td>
<td width="62">&nbsp;</td>
<td width="150">&nbsp;</td>

```



```
</form>
</div>
<div id="content" style="height:200px; width:180px;">
</div>
<div id="footer">
<br/>
© 2015 Ministry Of Transport
</div>
</div>
<div id="dialog"></div>
</body>
</html>
```